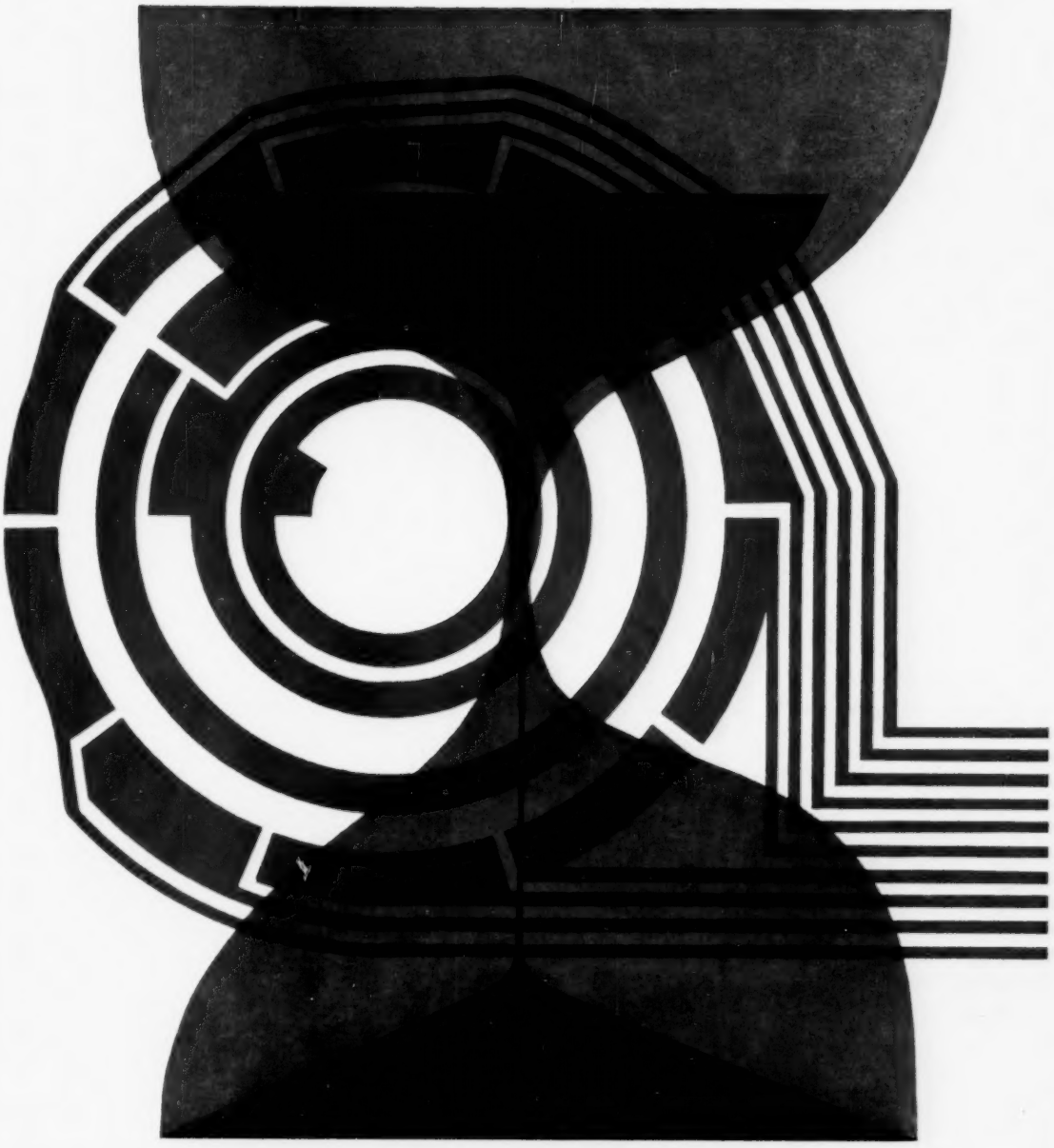
INSTRUMENTS AND CONTROL SYSTEMS

AUGUST 1960 INCLUDING: INSTRUMENT MANUFACTURING • JOURNAL OF THE SCMA • SIMULATION COUNCIL NEWSLETTER



in this issue:

IFAC Congress, Moscow, 1960	1279
Gray-to-Binary Conversion	1311
Plotting 12,000 PTS/SEC	1320
Timers	1324
Program Timers	1336
Pressure Calibration Lab	1344

CONTROL

ELECTROHYDRAULIC ARC FURNACE CONTROL

SHORTER MELT TIME

. . . for higher yields. Electrode speeds up to 30 ft./min. with safety and stability. Less time to bring electrode down to scrap at start; less time to recover arc after scrap falls away. Rapid short circuit elimination. Less electrode breakage through rapid pull-away on scrap cave-ins.

INITIAL COST REDUCED

. . . as much as 50%. Many components necessary for electric system are eliminated. Extremely simple electrohydraulic system uses a minimum of starters, contactors, rectifier systems, etc.

MINIMUM MAINTENANCE

. . . because hydraulic cylinders eliminate cable changes, gear train maintenance or replacement. No routine maintenance of control panel.

PERFORMANCE GUARANTEE

. . . from the supplier of the most reliable controls to the steel industry for a quarter of a century.

PROVED SUPERIORITY

. . . through the experience of leaders in high-quality steels and specialty metals, who are successfully meeting competition with GPE electrohydraulically controlled arc furnaces. Your GPE Controls representative has list of installations.

Write for descriptive literature

GPE Controls | A GENERAL PRECISION COMPANY

GPE Controls, Inc.
240 E. Ontario Street • Chicago 11, Illinois

A Subsidiary of GENERAL PRECISION EQUIPMENT CORPORATION

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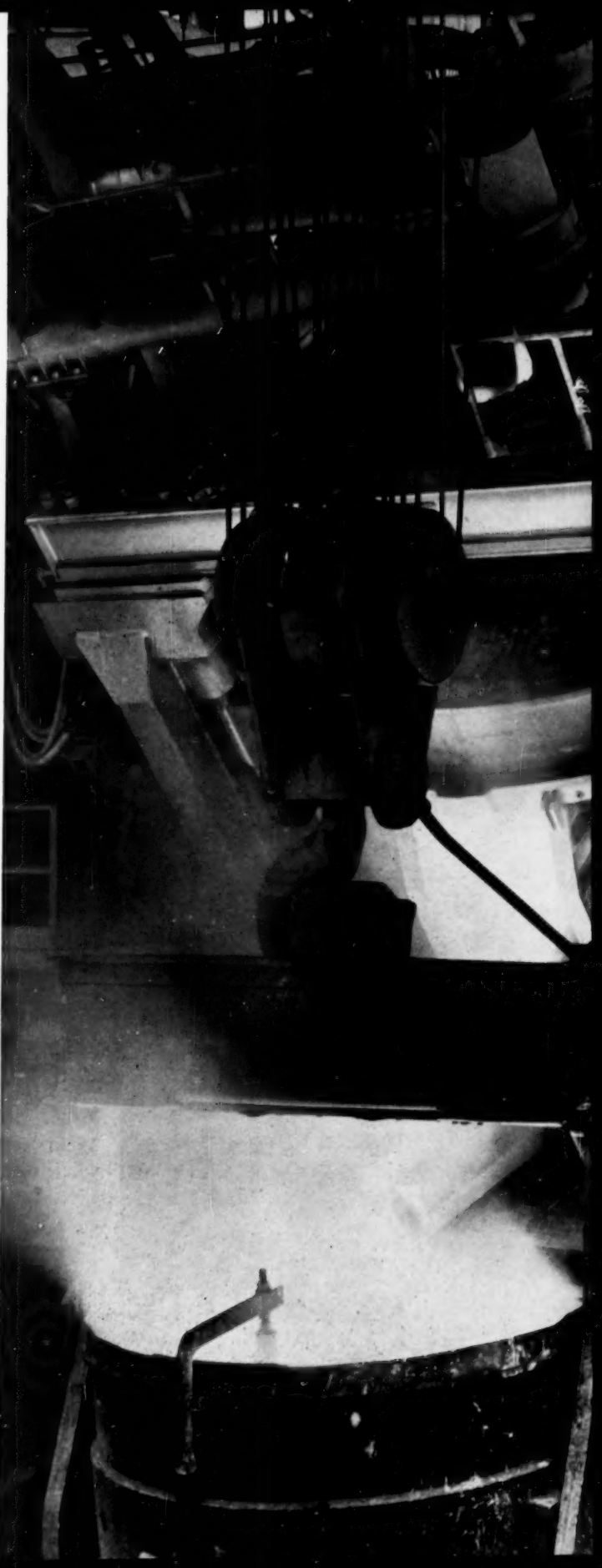


LEWIS

RESISTANCE THERMOMETER AND ACCESSORIES

The Model 62 RT4F Resistance Thermometer is a sturdy, easy to read instrument with a six inch hand drawn scale. It is suitable for use in moving vehicles, is excellent for flight testing or for permanent panel installations. Operated by an ordinary dry cell and calibrated to standard "AN" bulb curves, this instrument is ideal for use with any of the resistance bulbs illustrated below. Other ranges available in °C or °F.

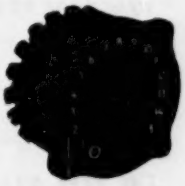
ACCESSORIES — RESISTANCE BULBS AND SWITCHES

Lewis Selector Switches have been used for years in automotive test work as well as in permanent installations. Simple, sturdy construction plus finest materials combine to give long service.

FREE AIR

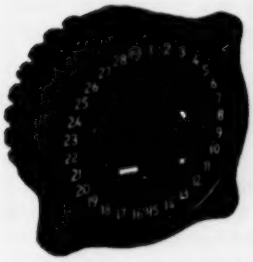
2" SIZE TO 4 POINTS

THREADED "AN" TYPE

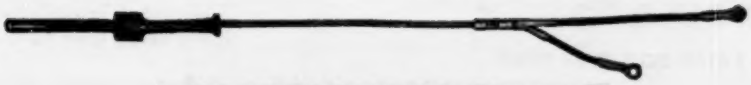


3" SIZE TO 20 POINTS

THREADED "AN" TYPE



4" SIZE TO 28 POINTS



BAYONET TYPE FOR CYLINDER HEAD TEMPERATURE

Lewis Resistance Bulbs are adaptable for use with the 62RT4F Resistance Thermometer or with standard aircraft panel indicators. Special purpose bulbs with stem variations or for high temperature applications are available.

We invite inquiries on your temperature measuring problems.

THE LEWIS ENGINEERING CO.

Manufacturers of *Complete* Temperature Measuring Systems for Aircraft

NAUGATUCK, CONNECTICUT

CIRCLE 2 ON READER-SERVICE CARD

A CASE OF *Accuracy!*

The "COMMANDER" Instruments described below have a 5-year accuracy guarantee. By using NBS or NRC reported values, total cumulative errors for a complete measurement system can be as low as ±.002%.

DAUPHINEE POTENTIOMETER TYPE 9144

ACCURACY ±.001%

A 7-figure (above 1 V.) DC vernier potentiometer with a total measuring range of 2.101010V. *Accuracy is at least 10 x that of similar commercially available equipment.* Direct readout on 4 dials in increments of .1 μv (no slidewire). Thermal emf's less than .5 μv on x 1 range and .1 μv on x .1 range. Contains 2 saturated standard cells in an internally thermostated enclosure. Completely "Self-Checking." *May be used with equal facility and accuracy as a Saturated Standard Cell or Resistance Comparator — and for the calibration of .01% accurate potentiometers.*

The Type 9144 is an original design by Dr. T. M. Dauphinee of the National Research Council in Canada. All rights are protected by a United States patent application.

VOLT RATIO BOX TYPE 9700

ACCURACY ±.005%

A volt ratio box similar to that used by the National Bureau of Standards as described by NBS Research Paper RP 1419. Self-heating and surface leakage negligible. Ranges: .15/.3/.45/.6/.75/1.5/3/4.5/6/7.5/15/30/45/60/75/150/300/450/600/750 V. (Type 9700A includes 1500 V. range). Furnished in a thermostated oil bath with a motor-driven impeller.

CONSTANT TEMPERATURE STANDARD CELL ENCLOSURE TYPE 9152 AND SATURATED STANDARD CELL TYPE 4305

ACCURACY ±.001%

Enclosure accommodates up to 4 cells and is air thermostated at 28°C ± .025°C. Transistorized circuit. Operates on 110V/60 cps (Battery standby).

THE TYPE 5214 GALVANOMETER AMPLIFIER AND TYPE SR21 LIGHT SPOT GALVANOMETER.

The amplifier operates on the differential photocell principle in conjunction with a liquid-filled primary galvanometer. The secondary galvanometer has a scale length of 120-0-120 mm and is stable and free from the effects of external vibration. Over-all sensitivity is approximately 350,000 mm/μa and 35,000 mm/μv. It is ideally suited for use with the type 9144 potentiometer.

Sensitive Research "COMMANDER" Instruments are manufactured by Guildline Instruments, Ltd. (formerly Tinsley Instruments (Canada) Ltd.)

VISIT BOOTHS 511-512 AT WESCON

SENSITIVE RESEARCH INSTRUMENT CORPORATION

NEW ROCHELLE, N. Y.

ELECTRICAL INSTRUMENTS OF PRECISION SINCE 1927

CIRCLE 3 ON READER-SERVICE CARD

INSTRUMENTS AND CONTROL SYSTEMS

TIME is one of the most important variables in all operations. Available devices and techniques are discussed, starting on page 1324.

VOLUME 33
NUMBER 8

AUGUST
1960

EDITORIAL

IFAC Congress, Moscow, 1960 1279
R. OETKER—A special I&CS report on the first congress of International Federation of Automatic Control

What Variables Can't You Measure Satisfactorily? 1280

FEATURE ARTICLES

Economic Dispatch 1304
REPORT on a pioneering computer-control system

Analog Computers in the Electrical Engineering Department 1307
GRANINO A. KORN—use of modern electronic analog-computing techniques in graduate and undergraduate courses

Gray-to-Binary Conversion 1311
ROBERT BROOKS—serial conversion of gray to binary code can be implemented by a basic flip-flop package

Decade Counting 1314
ED BUKSTEIN—ten different ways flip-flops can be connected to make a decade counter

Plotting 12,000 PTS/SEC 1320
HEART of the system is the Charactron shaped-beam tube

Timers 1324
DEVICES and techniques employed in the art of timing—a staff survey

Program Timers 1336
G. GORTEN, R. JOHNSON, and R. SMITH—comparative characteristics of various timer configurations

Time Standards 1340
A. G. MCNISH—the quest for precision in measuring time may well establish standards enabling us to learn what physics lie beyond the decimal point

Time Code on WWV 1341
NBS station WWV is now broadcasting an experimental time code of 36 bits at 100 pulses per sec

Pressure Standards Lab 1344
CHARLES E. WHITE—instruments used and resultant measurement accuracy capability of a standards lab

Standardized Tests for Ball Bearings? 1346
A. H. MASCHMEYER—unlike torque testing, there has been no effort to standardize bearing vibration characteristics

Ferroelectricity with Ferrimagnetism 1347
NBS has discovered a ceramic that has both ferroelectric and ferrimagnetic properties

INSTRUMENTS AND CONTROL SYSTEMS

VOL. 33 NO. 8
AUGUST, 1960

PRINT ORDER THIS MONTH: 39,100

Improved McLeod Gage **1350**

ROGER GILMONT—an open capillary now can be used to measure low pressures

Process Control Systems **1358**

FRED D. MARTON—combustion control for medium-size oil-fired steam plant; cascaded control resets fuel-gas flow controller to keep distillation-tower feed at constant temperature; edge guide control by photoeye

SOCIETY PUBLICATIONS

The Simulation Council Newsletter **1293**

Tying Equipment To Analog Computers 1293
Hermann on Economic Dispatch 1293
Parker on Airframes 1296
Mauersberg on Hypersonic Tunnel 1297
Gordon and Pritsker on Flight Games 1299
Calendar of Computer Events 1303

Journal of the Southern California Meter Association **1562**

Application of Chromatography To Natural Gas Analysis by E. L. ERICKSON

OTHER REGULAR FEATURES

Letters to the Editor 1228
Events 1232
Books 1233
Trends 1237
News 1238
New Applications 1240, 1248
Stock Report 1245
Briefs 1250
Panhandle Pete 1276
New Instruments 1368
New Literature 1427
Employment Opportunities 1433
Searchlite Section 1434
People in the News 1435
Advertisers' Index 1436
Inquiry Card 1437
Product Index 1438

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a new look in counters

AND NEW RELIABILITY, TOO

CMC was first to introduce the all-transistor 10 megacycle counter. Now CMC scores another important first with its complete new line of vacuum tube counting, timing and frequency measuring equipment. Note the clean, functional lines of these tastefully styled instruments... user engineered to eliminate costly "cockpit trouble". These instruments are the most reliable vacuum tube counters ever built. In the counter-timer below, for example, nine tubes have been eliminated. New modular circuitry simplifies maintenance and reduces weight. Unitized construction is exceptionally rugged. And to further simplify matters, all models have three key components in common—input amplifiers, power supplies, and shaping circuits. In short, these instruments will give you long, trouble-free operation.

BUT SEEING IS BELIEVING—Your nearby CMC engineering representative will be happy to arrange a demonstration and provide complete technical data. Or you can write us direct Dept. 558.

CMC's Model 226B Universal Counter-Timer (1 mc) leads a complete new line which includes a 220 kc universal counter-timer, a time interval meter and a frequency-period meter.

PRICES:
Model 226B, $1175; Model 226BN, illustrated, $1445 with Nixies; Model 225C, $900; Model 203B, $995; Model 251B, $915. Rack mount $10 extra. F.O.B. Sylmar, California.

CMC

Computer Measurements Co.

A Division of Pacific Industries

12970 Bradley Avenue, Sylmar, California

Phone: EMpire 7-2161

SEE US AT WESCON, BOOTH 633

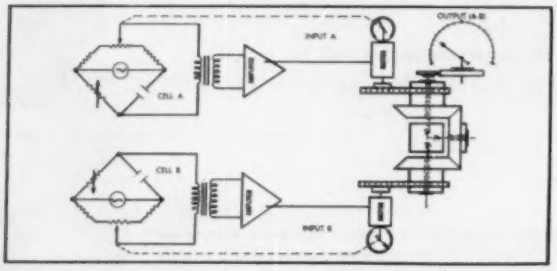
CIRCLE 4 ON READER-SERVICE CARD

Industrial Instruments Unveils
Advanced Line on Display

VERSATILE CONDUCTIVITY DIFFERENCE INDICATOR

Applications such as water treatment, chemical processing and others rely on conductivity difference as a means of measurement. In addition, analyzers for process control, dissolved gas measurements and other similar applications depend on conductivity difference for their operation.

The Conductivity Difference Indicator/Controller makes it possible to measure conductivity at two different locations. Each measurement can be manually or automatically temperature compensated. These two measured conductivities are used as the input to a simple mechanical device which has as its output, conductivity difference in the form of a shaft rotation.

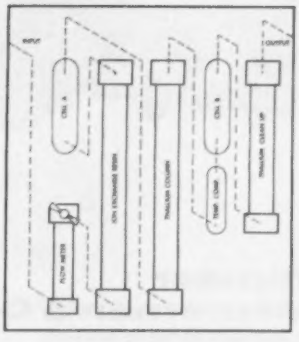


Alarms can be provided on both measured conductivity points as well as on the output difference measurement. The instrument can be supplied as an indicator, or indicator/controller, in which case all three variables (two inputs and one output) would have separate direct reading indicators. Units can also be supplied with a recorder driven by the shaft output. In addition, a retransmitting slide-wire or a pneumatic controller can be supplied as an output device.

For full details Circle 5 on coupon attached or use Reader Service Card

PORTABLE INSTRUMENTS FOR MEASUREMENT OF DISSOLVED OXYGEN

This instrument utilizes a unique property of metallic thallium which is extremely reactive to traces of oxygen in water while being inert to water itself. The reactive product is soluable thallous hydroxide which increases the conductivity of water. The instrument is a complete analyzer with conductivity cells, but less the measuring instrument. Several portable conductivity bridges manufactured by Industrial Instruments can be used with the analyzer. The portable analyzer consists of a mixed bed demineralizer cartridge and a packed column of pure thallium. The conductivity of the water is measured before and after passage through the thallium column, and the conductivity difference is directly related to the dissolved oxygen content in the water. For low concentration of oxygen in the ppb range, the sensitivity of the method is increased by demineralizing the water sample to decrease the background conductivity.



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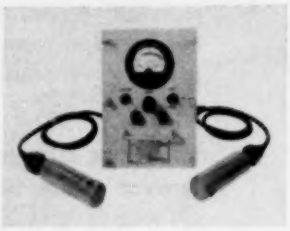
DEMINERALIZED WATER CONDUCTIVITY METER MEETS MILITARY SPECS

A new direct-reading type of conductivity meter designed for the measurement of conductivity of demineralized water is designated as RA-1. This new unit provides for conductivity measurements at two separate points with a switch on the front panel for selecting the appropriate conductivity cell. The scale is direct reading in megohms/cm specific resistance. All components are in accordance with applicable military specifications and the overall unit is designed to meet the shock and vibration requirements of military specifications.



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NEW MODEL PORTABLE CONDUCTIVITY INDICATOR

The Model RB-2 Conductivity Indicator is an AC Wheatstone Bridge type instrument, completely transistorized, for application requiring lightweight portability and long battery life. A center reading null meter is used to balance the bridge. Manual or automatic temperature compensation is available. The instrument is housed in a drawn aluminum splashproof case with convenient carrying handle. The instrument is useful for stream pollution surveys, well-logging, fisheries use and for conductivity measurements in industrial plants where portability and battery operation are advantageous.

For full details Circle 8 on coupon attached or use Reader Service Card

HELIUM LEAK DETECTOR

A new high sensitivity dual-range helium detector permits quick and precise location of helium leaks in tanks, piping, and other fittings. The two-range feature permits high sensitivity pick-up of small leaks, while minimizing overdrive of meter on large leaks.

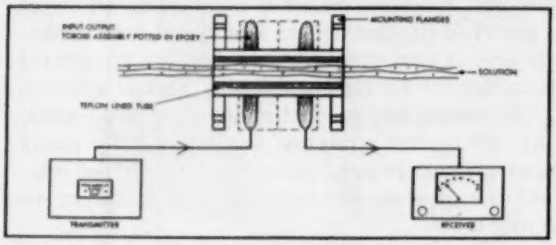
The thermal conductivity sensitivity detector is powered with mercury cells for long battery life. The unit includes a "transport position" on the range selector switch to short out the meter movement during transportation. The Therma Bridge Leak Detector can be calibrated for use with other gases.

For full details Circle 9 on coupon attached or use Reader Service Card

New Conductivity Equipment at I.S.A.-Booth 1406

ELECTRODELESS CONDUCTIVITY MEASURING AND CONTROLLING SYSTEM

Further development of the electrodeless conductivity system has resulted in improved techniques and basic changes which lower significantly the initial cost of equipment and permit its use in areas where cost has been a limiting factor. Automatic or manual temperature compensation can be supplied, and the unit is particularly applicable for difficult environments such as highly conductive materials and where slurries and fibrous material are present which will clog conventional conductivity cells.



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DIRECT READING GENERAL PURPOSE CONDUCTIVITY METER

When used with suitable conductivity cells, this instrument can be used for the measurement of conductivities ranging from distilled and demineralized water to concentrated acids and bases. The meter scales can be provided in a choice of micromho calibrations as well as in terms of concentration of solutions being measured. Output terminals provided for connection to standard millivolt recorder or controller. Manual or automatic temperature compensation can be provided.

For full details Circle 11 on coupon attached or use Reader Service Card

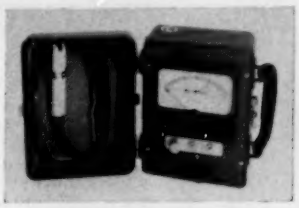
MAGNETIC AMPLIFIER CONDUCTIVITY CONTROLLER

For control applications requiring extreme reliability and freedom from maintenance, Industrial Instruments has developed the Model RGC-11 magnetic amplifier conductivity controller. In addition to iron-core transformer-like components, the instrument uses only a handful of capacitors, resistors and several diodes. This is an "ON", "OFF" controller with a heavy duty power-type relay output.

For full details Circle 12 on coupon attached or use Reader Service Card

DIRECT READING PORTABLE CONDUCTIVITY BRIDGE FOR FISHERIES USE

Designed specifically for application in fisheries, the Model RA-2 is a direct-reading portable instrument, completely transistorized for applications requiring lightweight portability and prolonged battery life. The instrument is direct-reading in micromhos/cm and ohm/cm and is housed in a drawn-aluminum gasketed and splashproof carrying case with handle.



For full details Circle 13 on coupon attached or use Reader Service Card

DIRECT READING CONDUCTIVITY METER FOR CAUSTIC MEASUREMENTS

This instrument is calibrated directly in weight percentage NaOH from 0 to 7%. It can be supplied with automatic or manual temperature compensation over the range of 110 to 200°F. Normally supplied with a selector switch to allow measurement at several different locations. Unit furnished in gasketed, splashproof housing.

For full details Circle 14 on coupon attached or use Reader Service Card

Industrial Instruments

Industrial Instruments INC.

89 COMMERCE ROAD, CEDAR GROVE, N.J., U.S.A.

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Address .....

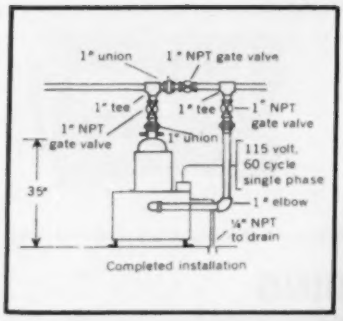
City ..... Zone ..... State .....

Shown for the first time at the I.S.A. Show will be the many new instruments and equipments described on these two pages. In addition, Industrial Instruments will have on display other advanced design instruments as well as a complete line of conductivity cells for every application. Be sure to visit us in Booth 1406.

SEE OUR COMPLETE LINE OF CONDUCTIVITY CELLS ON DISPLAY AT THE I.S.A. EXHIBIT

Now . . . Dehydration that is *Hankison*

See all 3 in Booth 312.



The F-30 Refrigifilter uses a 115 volt 50-60 cycle, single phase electrical source. The unit draws 8.1 full load amps.

For Medium Capacity Pneumatic Systems

Hankison's new Model F-30 Refrigifilter is the "Packaged Protection, Jr." of the line. It combines the functions of a condenser, separator, filter and trap (internal and external) in a package just 35" high and ASME coded. Equipped with a closed loop refrigeration cycle, it requires no cooling water, eliminates problems caused by ambient temperature variance. You can count upon atmospheric dew points of –5°F to –15°F, and cool dry air in your lines—exit air temperature is 52°F at rated capacity and 75°F ambient temperature.

It all adds up to this: Hankison's new model F-30—with a capacity of 30 SCFM—gives *medium capacity* pneumatic systems micro-clean, dehydrated, oil-free compressed air . . . protects them from rust and sludge conditions that lead to malfunction and costly equipment failure. And it does it by mechanical refrigeration – unmatched for efficiency and economy.

The F-30 is simple and easy to install—no prefilter or aftercooler is necessary and no special tools are required.

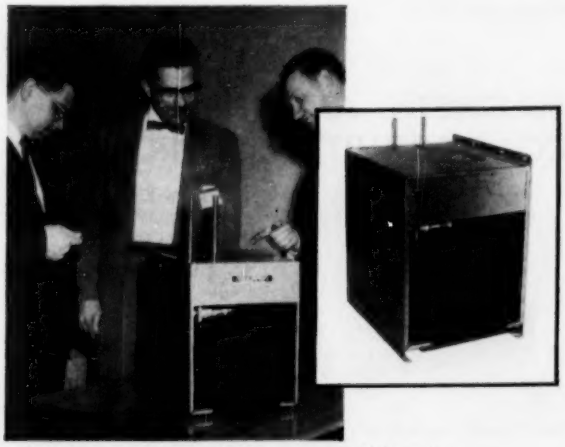
When completed, the installation is a neat self-contained "package" – see the diagram in the illustration above.

FOR F-30 REFRIGIFILTER—CIRCLE 15 ON READER-SERVICE CARD

For Commercial Air Conditioning Controls

The new Hankison Series-E non-cycling air dryer is the "Kid Brother" of the line, but it does a man-size job. It's an economy unit designed to provide clean dry air for air conditioning control systems, for processing and production lines requiring agitating, conveying, spraying, mixing, and for many other pneumatic applications that might not warrant the expense and high capacity of larger air drying units.

Operation of the Series-E Air Dryer – like the F-30 and F-100 Refrigifilters—is based on mechanical refrigeration, the most efficient, practical method known for drying air and gases. No cooling water is required; near-freezing dew points are obtained regardless of ambient temperature variations. Series-E Air Dryers are available with Hankison Mag-Pneu-Power Automatic Trap or Armstrong No. 21 trap and are also furnished tapped but without trap. They are housed in a sturdy steel cabinet, designed for easy mounting on floor or wall.



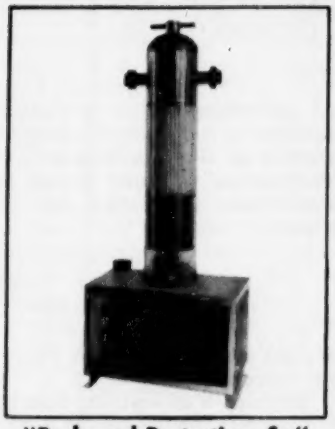
Hankison Series-E Air Dryers are being installed daily as a safeguard to modern air-conditioning installations all over the country.

FOR SERIES-E AIR DRYER—CIRCLE 16 ON READER-SERVICE CARD

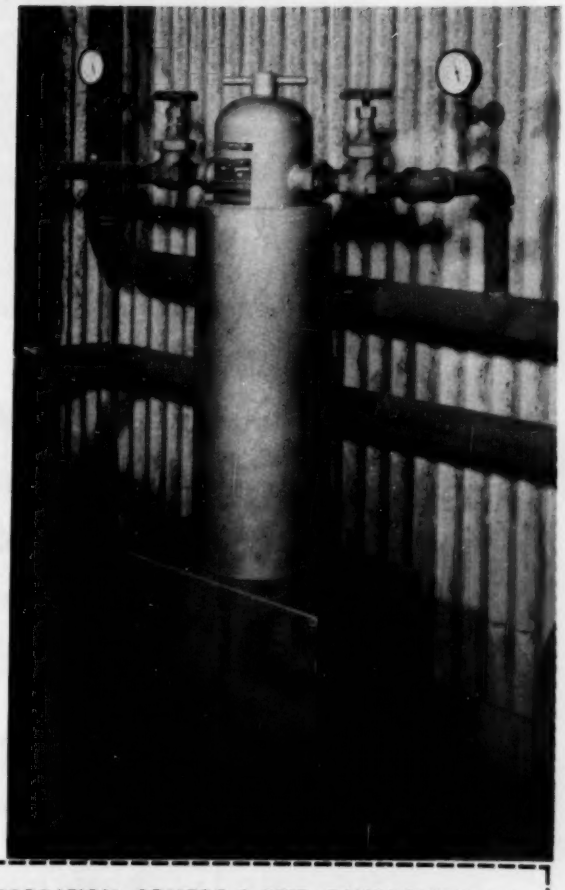
Efficient and Practical . . . with

Refrigerated Air Dryers

. . New York ISA Show



The Hankison F-100 Refrigifilter is a completely self-contained unit and installation is accomplished without the use of special tools.



"Packaged Protection, Sr."

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CIRCLE 18 ON READER-SERVICE CARD

I&CS LETTERS TO THE EDITOR

Editor, I&CS:

Your *Handbook of Electrical Measurements* is a goldmine of useful information . . . . I would like to see it in the hands of every EE and physics staffmember; then graduate students; then undergraduates.

Prof. C. Williamson
Dept. of Physics
Carnegie Institute of Technology
Pittsburgh, Penn.

Editor, I&CS:

I am writing to you in order to ascertain the possibility of obtaining information for a term paper on "Automation." I would greatly appreciate any information that will help me.

Joanne Hirsch
Wheaton College
Norton, Mass.

We get many such letters: Here is our answer:

"Enclosed is an editorial from *INSTRUMENTS AND CONTROL SYSTEMS* on "Automation and Economics," which you might be able to use in your term paper. We suggest also that you obtain the book *The Automatic Factory* ($2, Instruments Publishing Co.) for specific examples of automation at work in factories.

"The important things to keep in mind are:

"1. Automation is not new; it represents mankind's oldest instinct—do it automatically, if possible and economic.

"2. The economic health of a country depends on its productivity *and* purchasing power. Either one without the other means trouble. Automation increases only productivity—it has little and secondary effect on purchasing power, which depends on wage/price ratios, Federal expenditures, taxation amounts and policies, interest rates, etc., etc. Most persons discussing automation have not kept these two factors, productivity and purchasing power, in clear perspective.

"3. Where automation is economic it must be used by a progressive management for competitive reasons, and ours is a competitive economy. Thus there is no point to the discussion 'is automation a force for good or evil?' It is neither. The evil referred to implies economic factors, which, as stated above, are outside the realm of automation."

Editor, I&CS:

The reprinting of the 1960 *Handbook of Electrical Measurements* of (a portion of) my paper on *Local Standards Laboratories* leads me to call attention to an important development which has come about since that paper was presented at a symposium of the Instrument Society of America in St. Paul, Minnesota on January 17, 1958.[1] At that time it was anticipated that a moderate number of standards laboratories would be established by industrial organizations and government agencies to provide on-the-spot calibration services. We did not then foresee the great number of standards laboratories that have been or are now being established, nor did we realize that the laboratories in the larger organization would be organized into systems, and that each system would have a central laboratory to serve as an intermediary between the National Bureau of Standards and the local laboratories.[2] Some of the larger systems are comprised of three echelons of laboratories. In the Air Force, for example, a central laboratory at Dayton Air Force Base provides calibration services for 16 Air Materiel Area Standards Laboratories, and these, in turn, serve about 160 Base Laboratories. These systems of laboratories not only provide an efficient means of maintaining uniform and correct standards throughout a large organization, but they also render valuable assistance in staffing, equipping, and managing the local labs.

The organization of local laboratories into systems is highly advantageous to the National Bureau of Standards because it reduces the workload by enabling the Bureau to deal with a small number of high-level laboratories which act, as it were, as distributing agencies for standards. Thus a larger proportion of the Bureau's effort can be devoted to the important task of providing more accurate national standards.

In the reprinting of the paper on *Local Standards Laboratories* it is unfortunate that the error of substituting "distance" for "length" was not corrected. The prototype meter is, of course, a unit of length and was so designated in the manuscript.

A. T. McPherson
Associate Director
National Bureau of Standards
Washington, D. C.

1. Instruments and Control Systems, Vol. 32 pp 92-93 (Jan. 1959).

2. A short review of recently developed systems of laboratories is given in an article entitled "Standards and Calibration Activities in Rapid Growth," in the December 1959 issue of the National Bureau of Standards **Technical News Bulletin.**

hays

RAMBLINGS ON INSTRUMENTATION

The Temperature Measurement Caper

A chapter from "Mike Pipewrench, Private Eye" a new Service Training Manual we are preparing.

I'm crazy to get mixed up in this, I told myself as another .45 slug ripped my shoulder. Me, Mike Pipewrench, private eye. A blackjack glanced off my upper lumbar as I dragged myself to the window.

Inside, a hunched figure watched a weird machine. Little Rocco himself! Was I too late? I flung my six feet, nine-inches of bone and gristle over the sill, crouching for a catlike leap.

The hunched figure crawfished toward me, a Luger dangling from his clawlike fist. "You'll never get the secret, Pipewrench!" he screamed.

"Get smart," I told him, biting off the words. "You can't keep your formula for distilling gin from soybeans from the world forever." The Luger spouted flame and I clutched my other shoulder, fighting to control my temper.

"This is it, Pipewrench," cackled the hunchback. "You thought you'd found the secret when that showgirl at the Flamingo told you my process involved control of recycle gin, didn't you?"

I stalled. "What really tipped me off was when she mentioned a Hays *pneumatic* control." I kept a straight face as a slug ripped my solar plexus.

"That's right!" he shouted gleefully. "A Hays *pneumatic* control!"

I sneered, "Any child knows Hays doesn't have pneumatic control. Just electric controls. Best in the world. Joe Hays would spin in his grave if the company ever went in for pneumatic controls!"

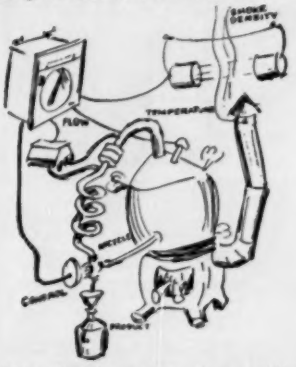
A willowy blond dashed into the room. "Mike!" she gasped, plastering herself against me. "Mike, I was going to tell you, honest. Hays *does* have a pneumatic control. It's made especially for them by . . ." The Luger cracked again and she collapsed on the floor.

I bent over her. "Made by who?"

Her eyelids fluttered. "F . . . P . . . " she gasped. Then it was all over. It just wasn't my night.

Little Rocco was talking again, agate eyes fixed on me. "Take a good look at the machine, Pipewrench," he snarled. "You'll never live to squeal. Note how I've combined part of the complete line of Hays temperature measurement instruments for precision recording of the distillation process."

A redhead in a leopard skin leotard slinked into the room. Little Rocco babbled on. "Note that the temperature of the gin is measured and recorded here on the Hays Universal Recorder, a Pneumatic Controller loading the pneumatic valve. Concurrently we obtain linear record of the square root flow characteristic of the gin, and . . . in the *fourth* recorder position . . . measure and record the nonlinear density of smoke from the fire."



"Stool pigeon!" the redhead screamed. Something flashed in her hand and Little Rocco writhed on the floor, the carved handle of a Javanese shiv between his shoulder blades.

"Nice work, baby," I told her. "He was too dangerous to live."

"He was about to spill the beans that the addition of the Hays Radiation Pyrometer would permit temperature measurement with the recorder beyond the 2500-2700° F. limit of the thermocouple," she pouted.

Somewhere a saxophone blared moodily. "I can't believe it," I muttered. "Hays *pneumatic* controls!"

"Everything changes, lover man," she said huskily.

I pushed her away. "Where did Rocco get his info?"

"No, no, Mike! Ask me *anything* but that!" I forced open her clenched fist. A crumpled paper dropped to the floor. As I bent to pick it up, I felt a shiv slip between my sixth and seventh ribs.

"Sorry, Mike," she sobbed.

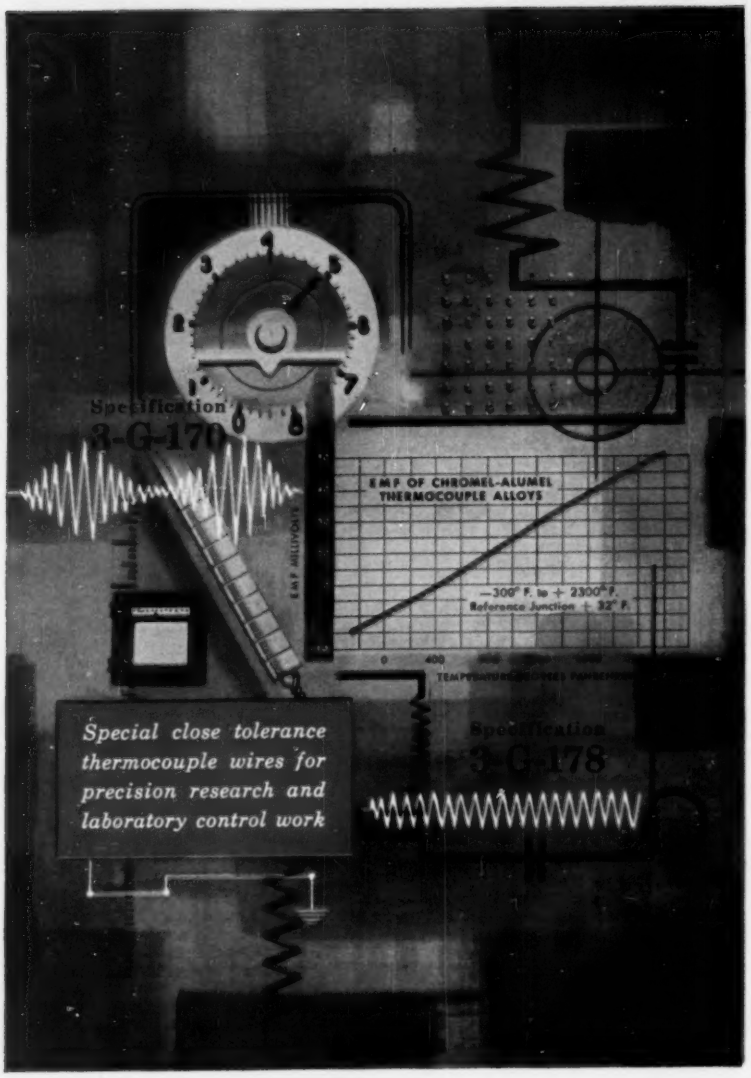
I patted her cheek. "See you around, baby," I rasped.

I spread open the paper, flicked my hard blue eyes across it and swallowed it. "Hays Bulletin 60-B771-CP," I repeated. Only one thing to do—destroy those bulletins before people began writing for them. The saxophone bleated through the dark. I had a headache. It was one of those nights.

Phil Sprague Jr.
President

THE HAYS CORPORATION • MICHIGAN CITY, INDIANA

CIRCLE 19 ON READER-SERVICE CARD



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CIRCLE 20 ON READER-SERVICE CARD

ICS LETTERS TO THE EDITOR

Editor, I&CS:

Last month I was graduated from the Carrick High School. During my senior year, I was enrolled in the Automation Course at Allegheny High School. Those in the course gained knowledge of electronics, industrial controls, quality control, computers, radiology, spectroscopy, metallurgy, electrical measurements and non-destructive testing. The purpose of the course is to teach the principles of physics and chemistry behind modern industrial processes and engineering techniques by giving fundamental instruction in those processes and techniques themselves. Technical knowledge considered unnecessary for understanding these principles and theories is not included in the course of instruction. For instance:

We did *not* learn how to program computers—instead we learned about gates, flip-flops, binary arithmetic, and memory storage systems.

We were *not* taught how to use an emission spectroscope—we were taught about the Bohr atom, electron orbits, photons and quantum theory (and saw an emission spectroscope in operation).

We studied the use of derivative and proportional response in pneumatic and electronic process controllers—*not* the operation of the machines themselves.

We learned the function of the circuitry of a television set by tracing signals through its circuits; but we were *not* given instructions in trouble shooting a defective receiver.

The existence of this course is justified if only for the reason that it is the best possible vocational counseling for future scientists and engineers, because the students met men of these professions, heard them talk about their work and discussed their work with them.

The most important requirement for a course of this type is an instructor who prefers sitting among the members of the class and discussing their questions with them, instead of standing before them and lecturing to them. We are fortunate to have Mr. Replogle, formerly of Carrick High School, as an instructor who fits this requirement well.

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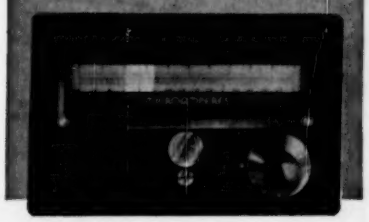

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CIRCLE 21 ON READER-SERVICE CARD

I will soon be making use of the knowledge I have gained in this course. I will be enrolled in the Electrical Engineering Department of Carnegie Institute of Technology, having been awarded a Westinghouse Scholarship.

Jan C. Siren
Pittsburgh 10, *Pa.*

This course comprises 2 classes per day, five classes per week for two semesters—emphasizing instrumentation and electronics. A full report was given in the editorial in the February 1959 issue of this publication.

Editor, I&CS:

I would very much like to have a copy of the editorial "Report on Public High-School Course in Modern Engineering Physics," which appeared in *Instruments and Control Systems*, Vol. 32, No. 2, February, 1959.

Any information on this matter will be greatly appreciated.

Roland Lauzon
National Research Council
Canada

Editor, I&CS:

In your May, 1960 issue of *INSTRUMENTS AND CONTROL SYSTEMS* an article was written by R. L. Farr on "Cutting Holes in Sheet Metal."

I would like to have more descriptive literature on his device for cutting holes in sheet metal including prices so that we would be able to distribute this to our construction personnel in the field.

M. F. Hess,
Johnson Service Company
Milwaukee 1, *Wisconsin*

Mr. Farr is at Goodyear Atomic Corp., Portsmouth, Ohio.

Editor, I&CS:

Ref: Sanista Company, Training of Instrument Engineer.

We wish to thank you for your letter and tear sheets covering various industrial instrumentation courses available from instrument manufacturers and schools.

We are contacting the universities you mentioned and several of the industrial firms. Thank you for your kind and courteous assistance.

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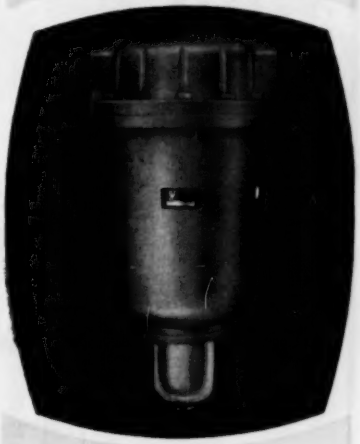

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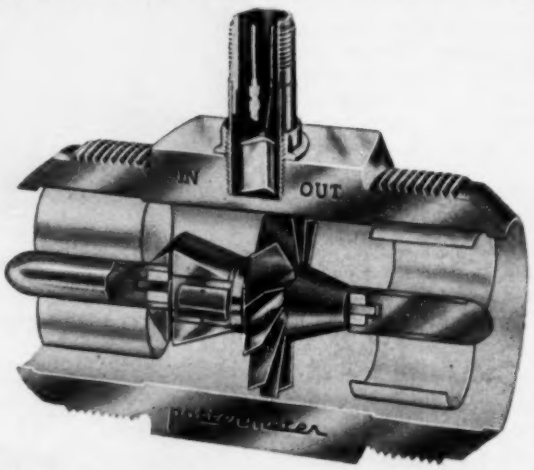

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CIRCLE 23 ON READER-SERVICE CARD

IGS EVENTS

August 29-31

Appalachian Gas Measurement Short Course, on campus of University of West Virginia. For information write R. E. Hanna, School of Mines, University of West Virginia, Morgantown, West Va.

September 6-8

Joint Automatic Control Conference, on campus of Massachusetts Institute of Technology. For information write Harvey A. Miller, JACC Program Committee IRE, Taylor Instrument Companies, 95 Ames St., Rochester 1, N. Y.

September 7-8

Second EIA Conference on Value Engineering, Disneyland Hotel, Anaheim, California. For information write J. A. Caffiaux, Electronic Industries Association, 650 Solmon Tower, 11 W. 42nd St., New York 36, N. Y.

September 7-9

1960 Joint Automatic Computer Conference, on campus of Massachusetts Institute of Technology. For information write JACC Chairman William D. Archibald, Energy Control Co., 5 Beekman St., New York 38, N. Y.

September 11-15

Third International Congress on Cybernetics, Namur, Belgium. For information write J. Lemaire, Secretariat, Association Internationale De Cybernetique, 13, Rue Basse Marcelle, Namur, Belgium.

September 11-17

American Society for Quality Control and I.R.E., Reliability Training Conference, Ft. Worth, Texas. For information write Henry Schifflett, Texas Instruments, Box 3-12, Dallas, Texas.

September 13-15

Fifth International Instruments & Measurements Conference, Stockholm, Sweden. For information write Helge Von Koch, Secretary-General, Stockholm 70, Sweden.

September 19-21

International Symposium on Data Transmission, Technische Hogeschool, Delft, Netherlands. For information write H. P. Williams, I.R.E., 1 East 79th St., New York 21, N. Y.

October 27-28

1960 Electron Devices Meeting, Shoreham Hotel, Washington, D. C. For information write H. W. Welch, Jr., I.R.E., 1 East 79th St., New York 21, N. Y.

I&S BOOKS

For more information on these books, or for publisher's book list circle number on reader-service card.

Direct Conversion of Heat to Electricity edited by Joseph Kaye and John A. Welsh, [c1960] John Wiley & Sons, Inc., 440 Fourth Ave., New York 16, N. Y., 356 + ix pp, clothbound $8.75. This book is designed to provide the starting point for new workers in this virgin field and to serve as a reference. It is a collection of papers of the new technology.

CIRCLE 216 ON READER-SERVICE CARD

Operations Research and Systems Engineering edited by Charles D. Flagle, William H. Huggins, and Robert H. Roy [c1960] The Johns Hopkins Press, Homewood, Baltimore 18, Md., 889 pp, clothbound $14.50. Book is a compendium on the meaning, use, and importance of these new fields. The first part of the book deals with the history of the subjects. Part II is devoted to methodologies. Part III applies the principles and methods to actual case studies.

CIRCLE 217 ON READER-SERVICE CARD

Junction Transmission in Pulse Circuits, by P. A. Neeteson, [c1959] N. V. Philips' Gloeilampenfabrieken, Eindhoven, Holland, The Macmillan Co., 60 Fifth Ave., New York 11, N. Y., 139 pp, + Bibliography, + List of Symbols, 9", clothbound $5.50. Methods are given by which fundamental pulse circuits containing transistors can be analyzed to simplify their designs.

CIRCLE 218 ON READER-SERVICE CARD

Dynamische Vorgange in linearen Systemen der Nachrichten- und Regelungstechnik (Dynamic Actions in Linear Systems of Communications and Automatic Control) by Dr. Hans Kaufmann, [c 1959] R. Oldenbourg, 145 Rosenheimer Str., Munich, West Germany, 211 p., 9¼", clothbound $7.00. Author puts emphasis on giving simultaneous considerations to time and spectral response of communication systems when using the mathematical representation by Laplace transforms.

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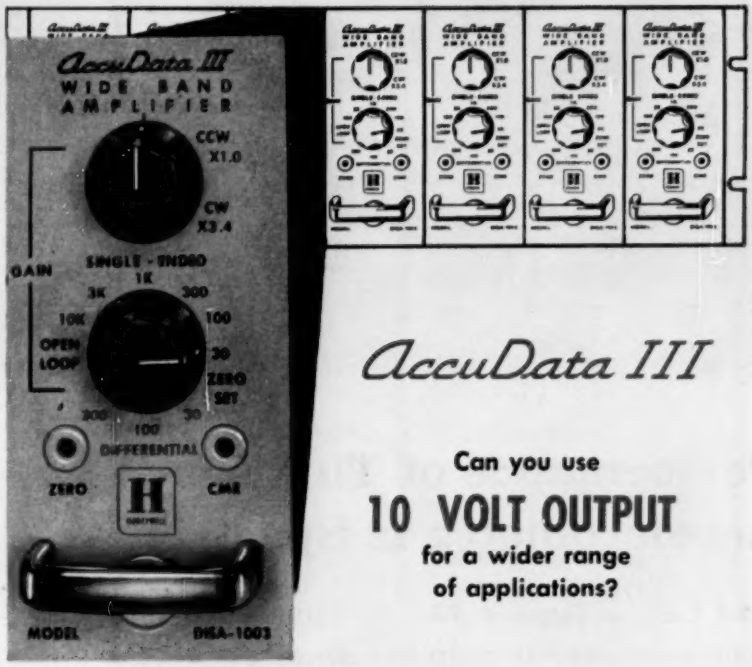

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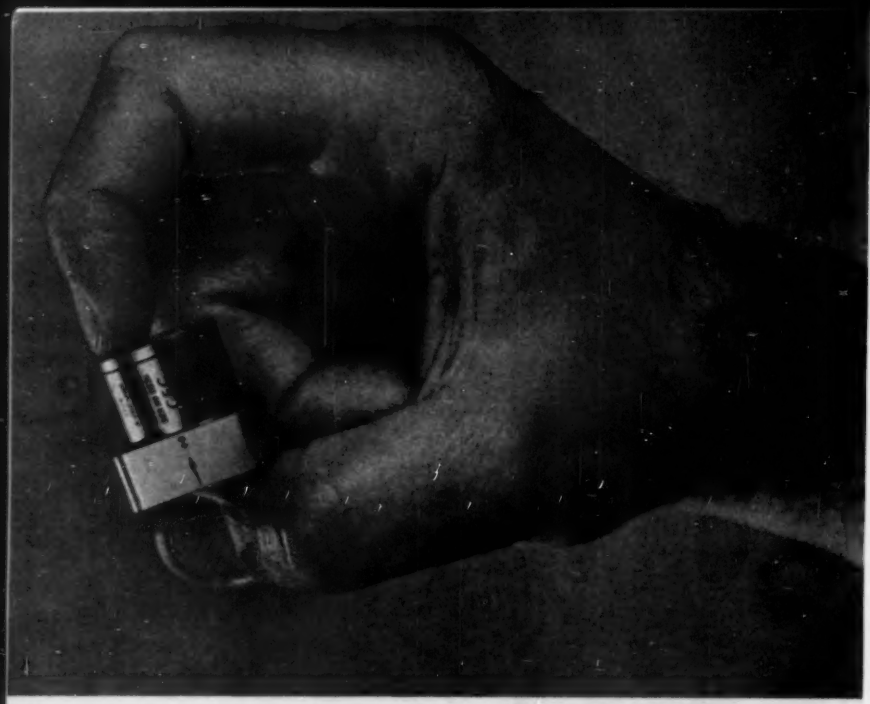

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ICS BOOKS

Circle number for additional information and publishers' book list.

Mess- und Regeltechnik (Measuring and Control Technique), Volume 35 of Dechema Monographs [c1959], Verlag Chemie GmbH, Weinheim/Bergstrasse; 327 pp., 8¼", paperbound DM39.40. Book contains 28 papers which were presented during the European Congress of Chemical Engineering and the Achema Congress 1958. Abstracts of the papers in English and French and a subject index are included in the volume.

CIRCLE 220 ON READER-SERVICE CARD

Progress in Non-destructive Testing, Vol. 1, edited by E. G. Stanford and J. H. Fearon, [c1958] Heywood & Co., Ltd, The Macmillan Co., 60 Fifth Ave., New York 11, N. Y., 267 pp., 9¾", clothbound $12.00. First in an annual series of international volumes containing critical reviews on the progress of the technology. Includes medical aspects.

CIRCLE 221 ON READER-SERVICE CARD

Analyses of Industrial Operations, edited by Edward H. Bowman and Robert B. Fetter, [c1959] Richard D. Irwing, Inc., Homewood, Ill., 485 p., clothbound $9.55, 9¼". Shows application of quantitative methods in actual case studies.

CIRCLE 222 ON READER-SERVICE CARD

Advances in Astronautical Sciences, Vol. 4, distributed by Plenum Press, Inc., 227 West 17th St., New York 11, N. Y., 459 p., 10" clothbound $8.00. Volume represents Proceedings of the Fifth Annual Meeting of the American Astronautical Society held in December, 1958, describing the state of the art of current astronautical research, including space vehicle design, rockets and satellites, guidance and instrumentation, etc.

CIRCLE 223 ON READER-SERVICE CARD

Graphic Aids to Frequency Responce Study and Feedback Control Systems published by Boonshaft and Fuchs Inc., Hatboro Industrial Park, Hatboro, Penna., 11", paperbound $5.00. Workbook contains a comphehensive set of graphs of linear transfer functions and nonlinear describing functions. Also 50 transparent Nichols Charts are provided for plotting on the linear terms.

CIRCLE 224 ON READER-SERVICE CARD

← CIRCLE 25 ON READER-SERVICE CARD

From Honeywell

A compact inexpensive controller

- **Automatic temperature control**
- **Automatic pressure control**
- **Automatic control of liquid level**
- **Automatic humidity control**

Exclusive Honeywell Versa-Tran replaces old fashioned mechanical control *at low cost.*

Now—a transistorized controller that's versatile enough to be used in many applications. Small, compact, with complete repeatability. No tubes, no warm up time, gives instant reaction. Works with sensors that can be thermistors, probes, resistance bulbs, pressure transducers or humidity elements. Can be used in such varied applications as packaging machines, injection molding machines, cooking vats, tire recapping, ice cube makers, and tanks, etc. Has a temperature control range from minus 60 degrees to plus 1400 degrees F.

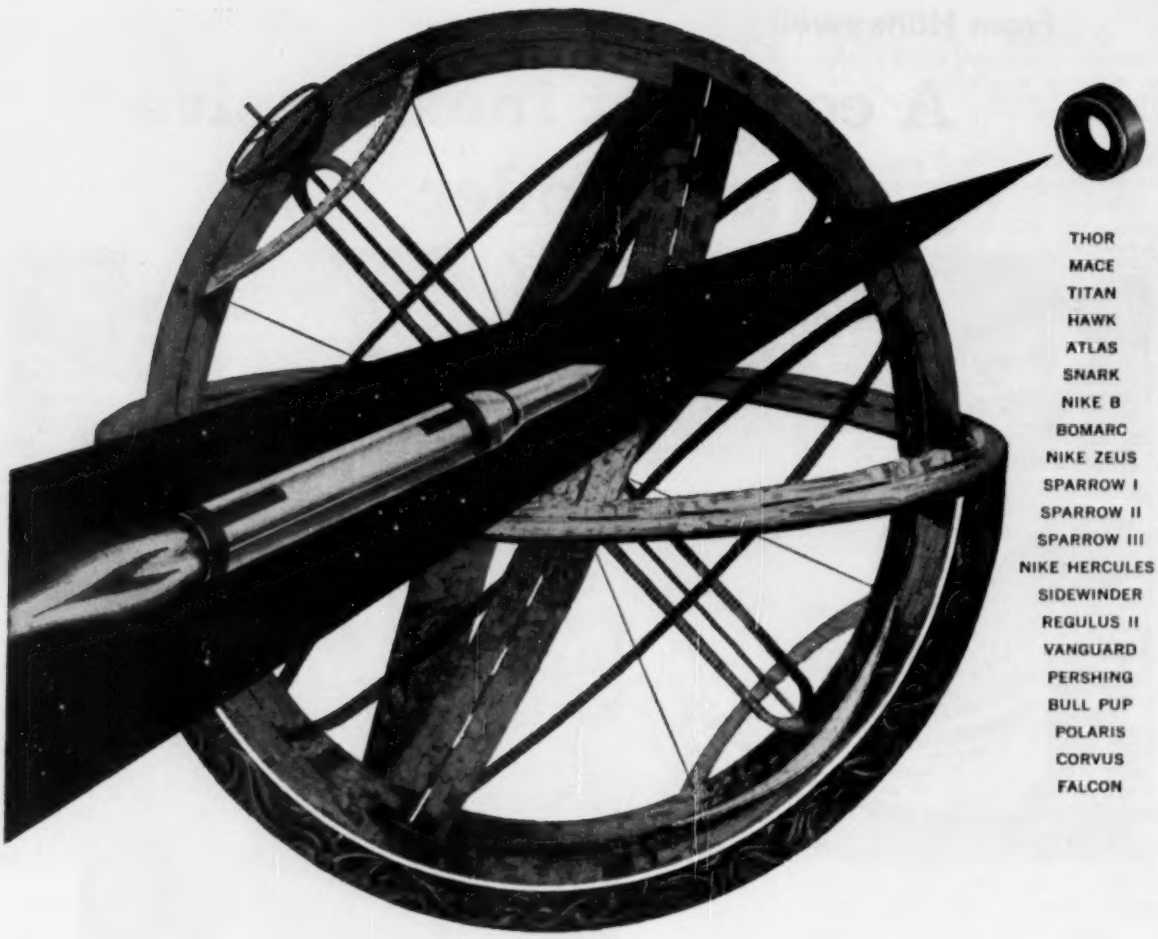
The Versa-Tran is the result of traditionally superior Honeywell engineering. For information, call your nearest Honeywell office and our industrial control sales engineer will call. Or write: Minneapolis-Honeywell, Department IC-8-24, Minneapolis 8, Minnesota. In Canada, write: Honeywell Controls Ltd., Vanderhoof Avenue, Leaside, Toronto 17.

Honeywell

75th YEAR PIONEERING THE FUTURE

H HONEYWELL *First in Control*

CIRCLE 26 ON READER-SERVICE CARD



THOR
MACE
TITAN
HAWK
ATLAS
SNARK
NIKE B
BOMARC
NIKE ZEUS
SPARROW I
SPARROW II
SPARROW III
NIKE HERCULES
SIDEWINDER
REGULUS II
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BULL PUP
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N/D Adds New Dimensions To High Speed Gyro Rotor Bearings!

At speeds up to 24,000 RPM precision rotor bearings in inertial guidance and navigational systems are highly critical components. Early research and development in design and manufacturing at New Departure is solving the problem and thus winning vital roles for N.D. integral rotor bearings in missile projects. For example, "B" Series bearings with separable inner ring developed by N.D. are helping set performance records in such inertial guidance systems as the AChiever.

New Departure is also supplying high-precision rotor bearings for the inertial guidance system in Polaris.

These bearings, through advanced manufacturing techniques, exacting inspections and controlled environmental tests, backed by 50 years of laboratory testing experience, give precision and uniformity far above the most precise industry standards. They promise new performance and *reliability* for the submarine-launched IRBM.

You can look to improved *performance* and *reliability* when you include an N.D. Miniature/Instrument Bearing *Specialist* in early design level discussions. Call or write Department L.S., New Departure Division, General Motors Corporation, Bristol, Connecticut.

DON'T MISS N/D'S EXHIBIT!
BOOTH 207
INSTRUMENT SOCIETY OF AMERICA EXHIBIT

NEW DEPARTURE

MINIATURE & INSTRUMENT BALL BEARINGS

proved reliability you can build around

CIRCLE 27 ON READER-SERVICE CARD

"Fifty percent of the country's scientific manpower is being used in military programs."—Secretary of Defense McElroy.

Static relay sales are now about $250,000, mostly military R&D, says R. Blake of Walter Kidde, but will reach $15-20 million in 1963.

1960 sales of precision, high-performance slip rings will total $10 million, estimates George Pandapas, president, Electro-Tec Corp. This excludes $10-million captive market and slip rings made for use with synchros and resolvers.

Industrial and Commercial Electronics estimate of dollar value is reported by F. Mansfield as follows (in millions):

	1956	1957	1958
Testing and Measuring Equipment	$170.0	$210.0	$220.0
Navigational Aids	70.0	95.0	100.0
Landmobile, Microwave, Broadcasting	120.0	150.0	155.0
Industrial Controls	115.0	150.0	160.0
Nuclear Instrumentation	22.0	27.0	35.0
Medical and Therapeutic	110.0	139.0	145.0
Commercial Sound	110.0	136.0	140.0
Communication	30.0	36.0	40.0
Miscellaneous	78.0	92.0	95.0
Total	825.0	1035.0	1090.0

The power station of thirty years ago had four separate control locations—one for the boilers, another for the turbines, another for the major auxiliaries, and one for electrical control. The efforts of a man were required to operate each 15 megawatts of installed capacity. Fifteen years ago, using the central control room, the need for operating personnel was reduced to one man for each 30 megawatts. Today, there are approximately 100 megawatts installed per operating position, says R. A. Baker, Public Service & Gas Co.

Marketed production of natural gas in 1959 showed a 6.7% gain over 1958. Average annual increase during the past 11 years was 7.9%. However, proved gas reserves only went up 2.6% and their rate of progression in the same 11-year period was 3.7% yearly. At the present rate of gas consumption (11.7 trillion CF) our reserves will last only 22 years at the present figure of 260.7 trillion CF. Conclusion: more gas must be found to satisfy future anticipated needs, says Oil Gas Journal.

Undergraduate enrollments at United States engineering colleges and universities dropped 5.4% last year. Freshman enrollment for engineering studies declined for the second straight year—this time by about 3%. Full-time and part-time undergraduates in engineering totaled 243,000 this year, compared with 257,000 in the fall of 1958 (From an announcement by Lawrence G. Derthick, Federal education commissioner, December 22, 1959.)

	Freshman Engineers	% Change From Previous Year	Total Undergrad. Engineer Enrollment	% Change From Previous Year	Total College Enrollment	% Change From Previous Year
1955-56	72,825	+11.2	221,448	+14.3	2,678,623	+ 8.8
1956-57	77,738	+ 6.7	251,121	+13.4	2,946,985	+10.0
1957-58	78,757	+ 1.3	268,761	+ 7.0	3,068,417	+ 4.1
1957-59	70,029	−11.1	256,779	− 4.5	3,258,556	+ 6.2

LPG industry, by 1960, may be selling 16 billion gallons of LPG for domestic and allied usage, and 10.5 billion gallons for chemical and other uses, say LP-Gas.

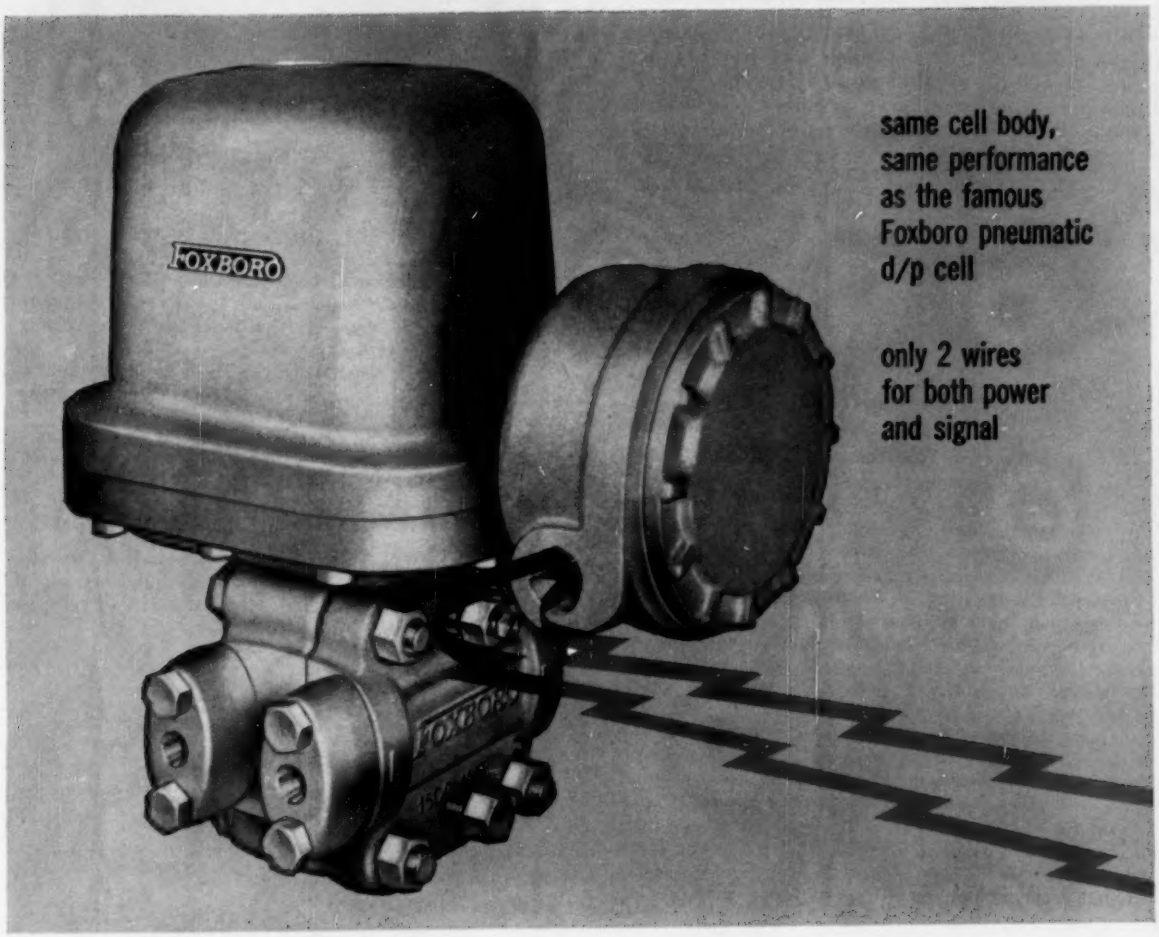
ISA Conference and Exhibit

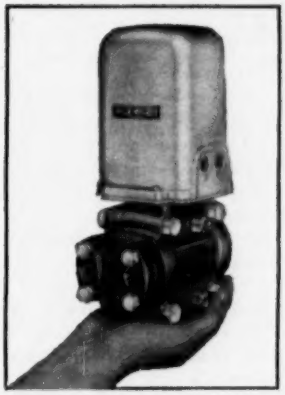
NEW YORK, N. Y.—The Fifteenth Annual Instrument-Automation Conference and Exhibit will be held September 26-30, 1960 at the New York Coliseum with "Progress Through Instrumentation" as the general theme. Scheduled for the preceeding Sunday, September 25, are Registration, beginning 9:00 AM, a Maintenance Clinic from 9 to 5, and the President's Reception from 4 to 6, all at the Hotel New Yorker. The annual Dinner-Dance will be held Wednesday at the Hotel Astor. Plant tours, student tours, and ladies activities round out the program. The Exhibit will stay open through Friday, 1 PM; the Conference closes on Thursday. New products on exhibit are reported in our New-Instrument department, starting on page 1368.

	Monday	Tuesday	Wednesday	Thursday
MORNING SESSIONS	10:00 Keynote Session	9:30 Research Instrumentation 9:30 Automotive Instrumentation 9:30 Strain Gage Instrumentation—Session I 9:30 Data Handling Workshop—Session I 9:30 Education Forum*—Session I 9:30 User Management Workshop—Session I 9:30 Underwater Instrumentation—Session I 9:30 Meteorological Instrumentation—Session II	9:30 Vibration and Shock Instrumentation 9:30 Mass Flow Measurement Panel 9:30 Metals and Ceramics Session 9:30 Process Analysis Instrumentation Session 9:30 Nuclear Instrumentation—Session I 9:30 Aeronautical Instrumentation—Session I 9:30 Standards Measurement Labs Workshop—Session I 9:30 Data Handling and Computation—Session I 9:30 Educator's Workshop 9:30 Underwater Instrumentation Session III	9:30 Control Computing Session 9:30 Lab Instrumentation for Analysis 9:30 Feedback Control Systems Session 9:30 Measurement and Control Instrumentation—Session I 9:30 Management and Economics—Session I 9:30 Computer Clinic—Session I 9:30 Underwater Instrumentation—Session V
AFTERNOON SESSIONS	2:00 National Lecture Series 2:00 Meteorological Instrumentation Session I	2:30 Strain Gage Instrumentation—Session II 2:30 Data Handling Workshop—Session II 2:30 Underwater Instrumentation—Session II 2:30 Meteorological Instrumentation—Session III 2:30 Education Forum—Session II* 7:30 International Progress in Automatic Control	2:00 Chemical and Petroleum Instrumentation Session 2:00 Nuclear Instrumentation—Session II 2:00 Aeronautical Instrumentation—Session II 2:00 Standards Measurement Lab Workshop—Session II 2:00 Data Handling and Computation Session II 2:00 Educator's Workshop 2:00 Underwater Instrumentation—Session IV	2:00 Process Chromatography Session 2:00 Measurement and Control Instrumentation—Session II 2:00 Management and Economics—Session II 2:00 Computer Clinic—Session II 2:00 Underwater Instrumentation—Session VI

Note: All sessions in Coliseum, except:* New Yorker Hotel

introducing the Foxboro electronic d/p cell* transmitter





The Foxboro electronic d/p cell transmitter and this Foxboro pneumatic d/p cell transmitter use the identical cell body. Only the top transmitting mechanism has been changed.

Yes, Foxboro has taken its famous pneumatic d/p Cell and added the benefits of electronic transmission. It's the new Foxboro *electronic* d/p Cell transmitter. Look at the results:

- both power and signal travel over the same pair of unshielded wires — no field power supply required
- pressure, flow, and level transmission up to several miles without lag
- true force-balance design for lowest displacement — highest overrange protection
- high level 10-50 ma d-c signal provides powerful rebalancing force
- adjustable ranges from 5" to 850" water with external zero adjustment — working pressures of 1500 and 6000 psi

And, of course, you get the same positive overrange protection, the same high sustained accuracy, the same rugged construction that has always been standard with the Foxboro d/p cell transmitter.

If you're thinking "electronic," it will pay you to investigate this important instrument in the Foxboro Electronic Consotrol* family. Get in touch with your Foxboro Field Engineer for complete details, or write for Bulletin 21-10. The Foxboro Company, 468 Norfolk Street, Foxboro, Massachusetts.

Reg. U.S. Pat. Off.

FOXBORO
REG. U.S. PAT. OFF.

CIRCLE 28 ON READER-SERVICE CARD

Medical Electronics

PHILADELPHIA, PA.—The Division of Research of Lankenau Hospital, in cooperation with Brown Instruments Division of Minneapolis-Honeywell, recently demonstrated application of an automatic data handling system in environmental studies.

The hospital division, under the direction of Dr. Kaare Rodahl, is conducting research to determine the effect of varying levels of protein diet upon individual performance capacity. The subjects' diets, which may be 1500 or 3000 calories per day, contain either 70 grams of protein or none at all. In the research program, which focuses attention to acclimatization to cold, the subjects are exposed in a climatic chamber for 10 days to a constant temperature of 44°F, wearing only shoes, socks, and shorts. At night they sleep on a mattress-less cot, covered only with a GI blanket.

Their temperatures are under constant automatic surveillance. Strapped to various locations on their bodies are sensitive thermocouples which feed their signals through a digital potentiometer into a Brown Analog-Digital Recorder-Transcriber. It prints out the digitized readings with resolution of 1 in 4000 by electric typewriter, or codes the results on punched cards or tape.

Other tests include recording of blood pressure and heart rates after the subject exercises on a bicycle or treadmill to near-exhaustion; use of a paramagnetic analyzer to determine maximum oxygen consumption; of an infrared analyzer to determine maximum oxygen consumption; of an infrared analyzer to measure expelled carbon dioxide; and blood-sample analysis.

FOR MORE INFORMATION CIRCLE 225 ON READER-SERVICE CARD

Data Storage and Display System

BOSTON, MASS.—Laboratory for Electronics, 1079 Commonwealth Ave., Boston 15, Mass., recently demonstrated a novel data storage and display system, called RASTAD which, when interrogated, displays the information on a 21″ viewing screen. Commands to the system are given by pressing buttons on a keyboard similar to that of a standard office calculator. In a matter of seconds the system displays on the screen an index of available reports and the drum, track, and sector numbers where each report is stored. A particular report can be selected, and by pressing a button, the index is erased. A few buttons are pressed again, and the whole report is displayed on the screen a few seconds later.

In the same way a map can be displayed, and information can be superimposed on certain areas of the map.

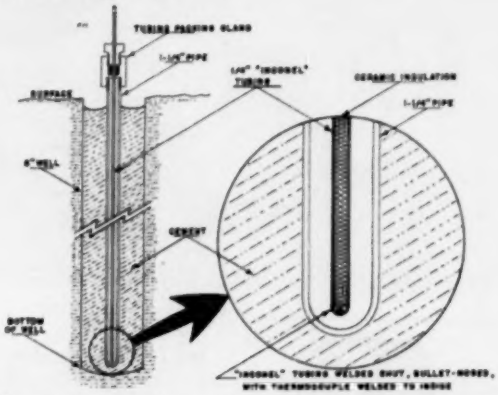
All this information is stored on a high-density magnetic file drum. RASTAD is compatible with virtually any computer system on the market.

With a storage capacity of 1.7 million alphanumeric characters on each drum, a total of 55 million characters can be stored.

FOR MORE INFORMATION CIRCLE 226 ON READER-SERVICE CARD

Inconel Tubing Protects Thermocouples Underground

NORRISTOWN, PENNA.—Gulf Research & Development Co., Pittsburgh, has an experimental program of underground combustion for the recovery of viscous petroleum deposits.

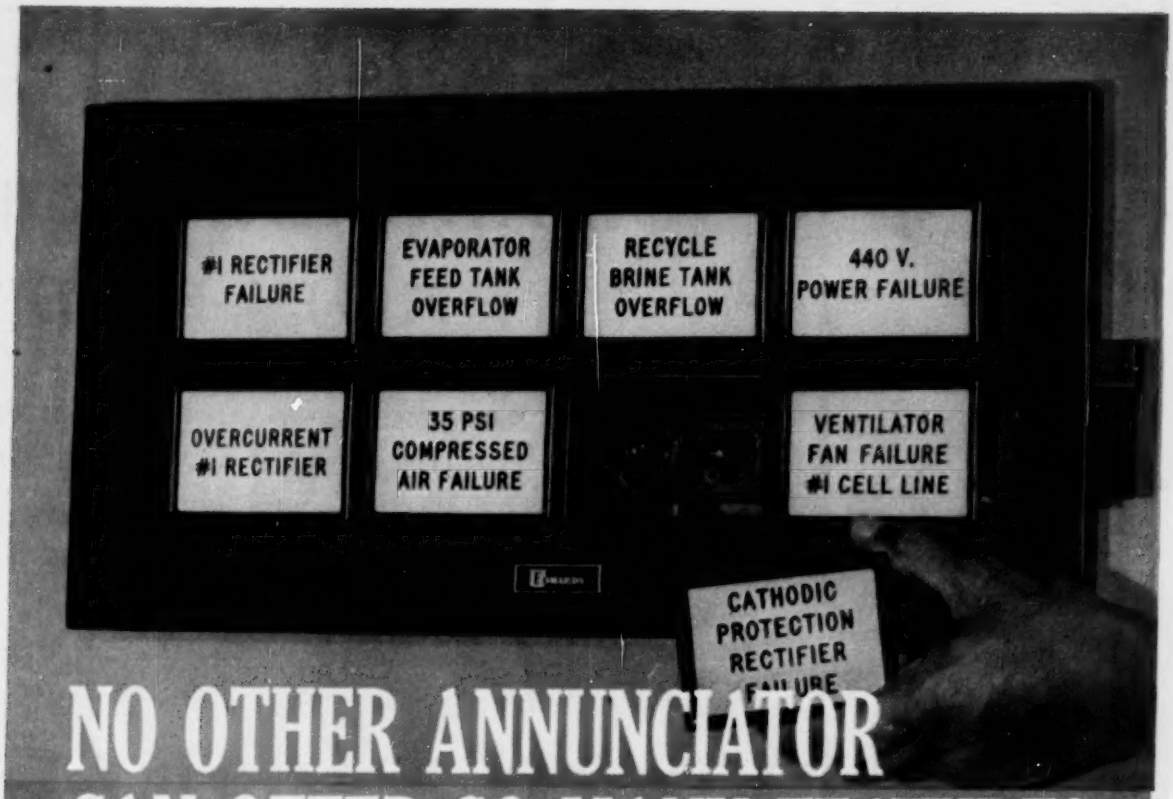


Inserted from the surface to the combustion zone, Chromel-Alumel thermocouples generate a thremoelectric force making it possible to determine the temperature of combustion, its locations, and the direction of its movement. Tubing protecting the thermocouple and its ceramic insulation has to withstand temperatures from below freezing to 2000°F, the corrosive effect of acids in water and water vapor, and the presence of oxygen at all temperatures.

Full hard Inconel tubing, supplied by Superior Tube Co., Norristown, Penna., in 120-ft lengths, as protective sheating for thermocouples has made possible thermocouple monitoring of these temperatures. Inconel tubing which has an OD of ¼″ and a wall thickness of only 0.035″ withstands insertion in oil wells to its entire length under pressure up to 300 psi without buckling.

FOR MORE INFORMATION CIRCLE 227 ON READER-SERVICE CARD

continued on page 1248


#1 RECTIFIER FAILURE
EVAPORATOR FEED TANK OVERFLOW
RECYCLE BRINE TANK OVERFLOW
440 V. POWER FAILURE
OVERCURRENT #1 RECTIFIER
35 PSI COMPRESSED AIR FAILURE
VENTILATOR FAN FAILURE #1 CELL LINE
CATHODIC PROTECTION RECTIFIER

NO OTHER ANNUNCIATOR CAN OFFER SO MANY FEATURES

Now from Edwards long experience in annunciator systems, comes a completely new line of lamp annunciators incorporating outstanding operational features . . . developed in cooperation with consulting engineers, leading power stations, chemical process and industrial plants. Design and operational flexibility is keyed to present and future demands of automatic process control and all types of automated systems. Edwards technical specialists in 58 cities across the country can show you how Edwards lamp annunciator systems can provide the most reliable flexible operation for every type of indication. Write for your copy of a new descriptive Bulletin A-200. Edwards Company, Inc., Norwalk, Conn.

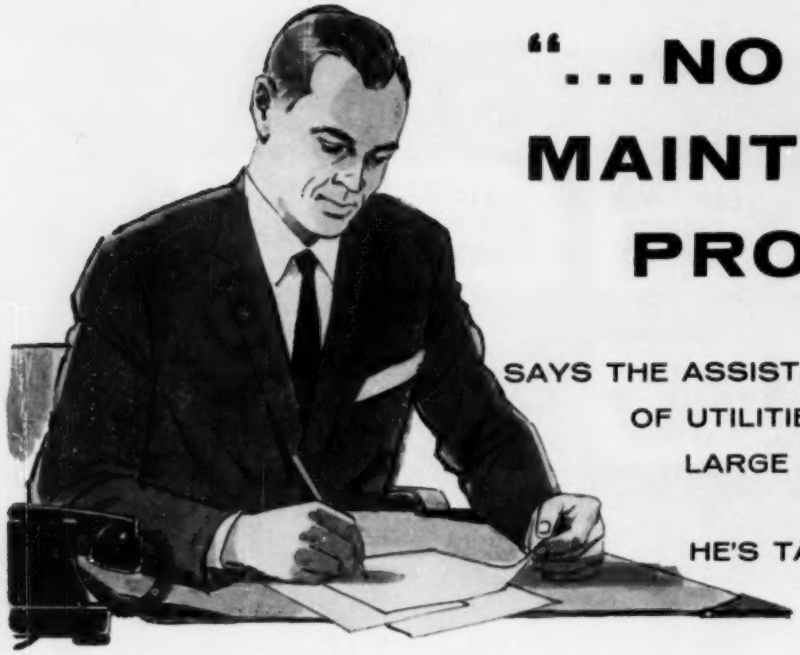
NO OTHER ANNUNCIATOR OFFERS YOU ALL THESE FEATURES:

Operation: 1. Operational sequences may be changed without altering terminals, connectors or jumpers, even while power is on. 2. Operation from normally-open or normally-closed circuit contacts may be easily changed after installation by merely plugging in the designated relay unit. 3. No power drain—no "dropping resistors" to burn out or cause internal heating. 4. Wide selection of operational sequences. 5. Simple specific purpose "plug-in" circuits. 6. Indicating circuit provides extra contacts and independent terminals for data logging or other control functions. 7. Test for all indicating lamps on annunciator as standard equipment. **Design:** 1. Complete modular construction for flexibility of application. 2. One-piece molded lamp compartment and indicating plates snap into position. 3. Long-life under-voltage, double contact bayonet lamps will not loosen. 4. Relamping from front without opening door. 5. Lamps in multiple, no signal loss in burnout. 6. Dust resistant, continuous gasket front and back. 7. No exposed live parts. 8. Circuits plug in—vibration-proof lock. 9. No mounting holes required for panel mounting types. 10. Long-life relays—high temperature insulation, diffused gold contacts of higher rating, nylon coil, sealed windings. 11. Hermetically-sealed relays available when specified. 12. Heavy-duty barrier-type terminals accommodates through No. 10 AWG wire.

EDWARDS

SPECIALISTS IN SIGNALING SINCE 1872 / FOR CONTROL • COMMUNICATION • PROTECTION / (IN CANADA: EDWARDS OF CANADA, LTD., OWEN SOUND, ONT.)

CIRCLE 29 ON READER-SERVICE CARD



"...NO MAINTENANCE PROBLEMS"

SAYS THE ASSISTANT SUPERINTENDENT OF UTILITIES OF A LARGE STEEL MILL*

HE'S TALKING ABOUT

CONOFLOW Series LB

When approached for a comparison of maintenance costs between Conoflow LB control valves and other control valves, he exclaimed, "There are no costs of maintenance on LB valves. We've never had any trouble with them!"

Such dependable, maintenance-free performance saves a plant like this tens-of-thousands-of-dollars in downtime annually. Consider the various trades that have to be called into action or held idle when a control valve must be taken out of a line, the capital tied up in idle machines, and loss of production.

Did you ever figure out what an hour's downtime costs in *your* plant? Wherever such figures are known, the Conoflow LB control valve makes "dollars-and-sense" savings that can't be beat.

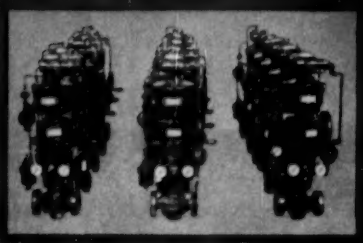
We show here only a few of hundreds of "testimonial" installations where users enthusiastically endorse Conoflow LB Valves.

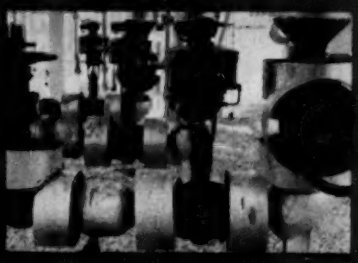
Let our representative give you an actual demonstration and tell you more . . . or write today for Bulletin LB, Conoflow Corporation, 2100 Arch St., Philadelphia 3, Pa.

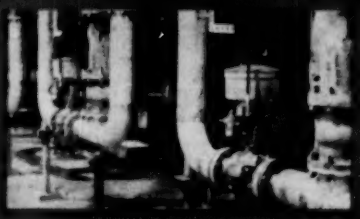
*Name on request

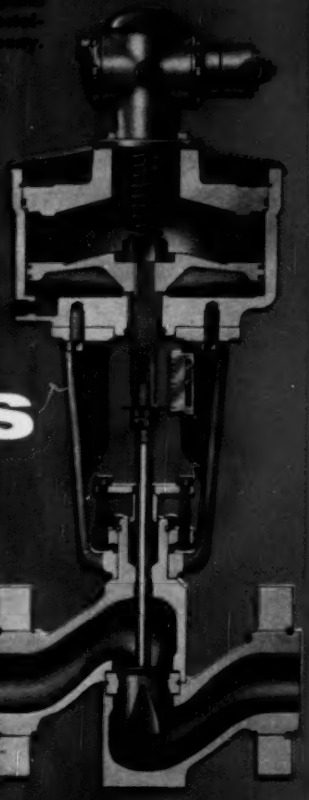
VISIT CONOFLOW BOOTH 1445, New York 1960 ISA SHOW, September 26-30

CONOFLOW CORPORATION . . .

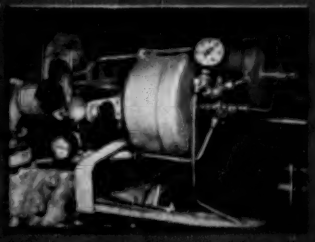


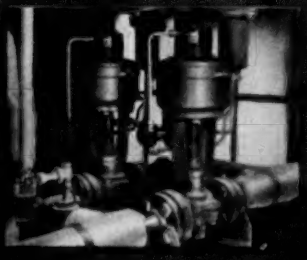


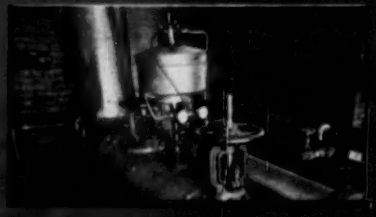


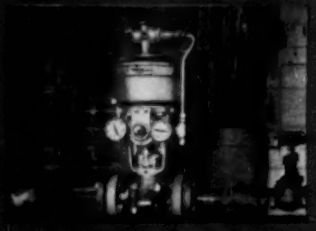


CONTROL VALVES









CIRCLE 30 ON READER-SERVICE CARD

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Potentiometers

Small but Accurate—unique design and production techniques assure exceptional functional accuracy.

SERIES C-050

½". Sealed, sub-miniature type with one-piece metal case and bearing. Completely enclosed. Solid terminals, integrally cored with molded covers. Rotation: 320° electrical, 325° mechanical, 360° continuous.

SERIES C-078

⅞". Weight only ½ ounce. Independent linearity: ±1% of total resistance is standard. Linear or non-linear windings on flat card. Fully enclosed. Tolerance: ±5% standard, ±1% on order.

SERIES C-178

1⅜". Sine-cosine units with peak-to-peak accuracies to 0.25%. Independent brush contacts on common shaft, 90° apart. Ganged types available. Also 2" and 3" diameters.

Panel Instruments

Ruggedized . . . round or square—miniature high precision units meet reduced size and weight requirements of aircraft and electronic applications

SERIES 100

1". Accuracy ±3% at full scale. Non-magnetic calibration. Scale length, 0.738". Background markings black or white, lance pointer, sealed solder lug terminals, aluminum housing. Watertight to meet MIL-M-3823 specs.

SERIES SC-031

½". Rugged, miniature sealed unit. Includes external pivot D'Arsonval movement and high flux density Alnico magnet. Optional mounting, face plate and hex nut.

SERIES 131

1½". Ruggedized to withstand shock, vibration or thermal extremes. Meets MIL-M-10304 specs. Positive watertight seal of meter and terminal studs.

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CIRCLE 31 ON READER-SERVICE CARD

IQS STOCK REPORT

Further information may be obtained from the Research Department, Bache & Co., 36 Wall Street, New York 5, N. Y.

NEW YORK STOCK EXCHANGE

PRICE RANGE FOR 1960 THRU JULY 15, 1960

	High	Low	Price As Of 7/15/60
ACF Industries	52	41 1/8	46
Aerojet Corp.	40 5/8	30 3/4	28 1/2 Bid 29 1/4 Asked
Allis Chalmers	40	27 3/4	27 3/4
American Chain & Cable	51 3/4	44	45
Amer. Mach. & Foundry	74 3/4	49 1/2	62
Amer. Mach. & Metals	58 1/4	44 1/2	44 1/2
American Optical	67	43 1/4	59 1/4
Amer. Tel. & Tel.	98 1/8	79 7/8	89 7/8
Ampex Corp.	42 1/4	30 1/2	35 5/8
Bausch & Lomb Optical	58 7/8	34 1/2	48 1/2
Beckman Instruments	103 1/2	62 1/2	88 1/4
Bell & Howell	57 1/2	37 5/8	47 5/8
Bendix Aviation	74 1/2	57 1/2	65 1/2
Boeing Airplane	32 3/4	23	28 5/8
Bullard	17 7/8	11	11 5/8
Bulova Watch	20 3/8	14 1/8	18 1/2
Burroughs	40 3/8	28 3/4	35 1/8
Carborundum	49 7/8	41 1/4	44 1/2
Cinc. Milling Machine	38 1/2	26 3/4	27
Clevite	71 3/4	42	62 1/2
Columbia Broadcasting Sys.	45 1/4	36 5/8	41 5/8
Consol. Electronics	60 3/4	42 1/4	50 1/2
Corning Glass	186	124	165 3/4
Curtiss Wright	31 1/8	16 1/2	19 3/8
Cutler-Hammer	96	82	86 1/2
Daystrom	49 3/8	35 3/4	41 7/8
Douglas Aircraft	42 3/8	27	28 1/4
Eastman Kodak	136 1/4	96	119 3/4
Eaton Mfg.	46 7/8	33	33 3/8
Electric Auto-Lite	54 1/2	44 1/2	47 3/8
Elgin Watch	19 1/8	11 1/2	15 1/2
Emerson Electric (new)	50	33	43 1/2
Food Mach. & Chem.	57 1/2	44 1/2	52
Garrett	54 7/8	44	48 1/2
General Controls	29 5/8	18 1/2	21 5/8
General Dynamics	51 3/8	38	42 5/8
General Electric	99 7/8	84 5/8	87
General Instruments	50 3/8	22 1/2	44
General Mills	31	23 7/8	27 1/2
Gen. Precision Equip.	66 5/8	44 1/4	56
Gen. Railway Signal	36 7/8	27 1/2	31 3/4
Gen. Tel. & Elect. (new)	37 1/8	27	28 3/4
General Time (new)	33 1/8	19 5/8	19 7/8
General Tire & Rubber	81 3/8	55 7/8	58 1/2
International Bus. Mach.	543 1/2	407 1/4	509
International Resistance	41 5/8	18 1/4	33 1/4
Internat'l. Tel. & Tel.	46 3/4	32	40 5/8
I-T-E Circuit Breaker	44 1/4	31 7/8	33
Lear Inc.	21 1/2	13 5/8	19
Litton Industries	96	57 5/8	83 3/8
Lockheed Aircraft	32 7/8	18 5/8	21 3/8
Magnavox	55	31 3/4	46
Mallory	90 1/4	60 3/8	64 1/4
Minneapolis-Honeywell	178 3/4	123 5/8	158 3/8
Minnesota Mining & Mfg.	88	65	70 7/8
Motorola	194 1/4	140	162 1/2
National Acme	54 3/4	47	47
National Cash Register	70 7/8	55 3/4	58 3/4
Neptune Meter	36 3/8	27 1/2	28
North American Aviation	42 3/8	29 5/8	40 3/4
Northrop Aircraft	38 3/8	24 3/4	33 5/8
Otis Elevator	58 1/2	36 3/4	51 1/2
Philco Corp.	38 1/4	26 3/8	27 1/8
Radio Corp. of America	78 3/8	59 1/2	64
Raytheon Mfg.	53 3/8	35 1/2	41 3/8
Reliance Electric	68 5/8	47 3/4	61
Rheem Mfg.	28 7/8	18 1/8	18 1/4
Robertshaw Fulton	55	43	45 1/4
Royal Mc Bee	21 3/8	15	15 3/4
Sangamo Electric	21 1/2	16	17 1/4
Siegler Corp.	43	29 1/4	35 5/8
Sperry Rand	26 1/4	20 1/8	23 1/8
Square D	37 7/8	28	27 5/8
Standard Kollsman (A)	30 1/2	12 5/8	23
Starrett (L.S.)	20	16	18
Stewart-Warner	33 1/2	23	28 1/4
Talautograph	10 1/4	6 7/8	8 1/4 Bid 8 3/8 Asked
Texas Instruments	256 1/4	154	214 3/4
Thompson-Ramo-Wooldridge	67 1/2	46 7/8	60
Tung-Sol Electric	40 1/2	31 1/8	33
Underwood Corp.	48 5/8	34 3/4	41 1/2
Union Carbide Corp.	148 1/2	126 1/4	136
United Shoe Machinery	64 3/8	50	55 1/2
Varian Associates	67 1/2	39 3/4	57 1/8
Wallace & Tiernan	56 1/2	41	38 1/4 Bid 38 7/8 Asked
Western Union	57	41 3/4	43
Westinghouse Air Brake	32 5/8	25 1/8	27 7/8
Westinghouse Electric	65	45 1/2	57 1/8
Worthington Corp.	66	47	47 3/8

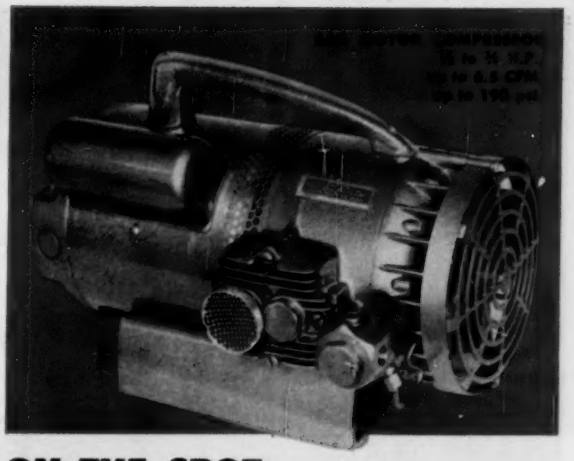
(1) Not Traded - Bid & Asked

These prices and price ranges are given as printed in the Wall Street Journal
(A) Formerly Standard Coil Products.

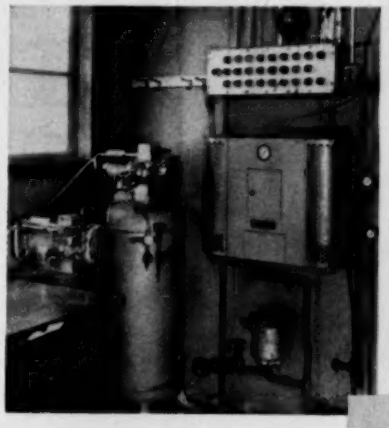
AMERICAN STOCK EXCHANGE

PRICE RANGE 1960 THRU JULY 15, 1960

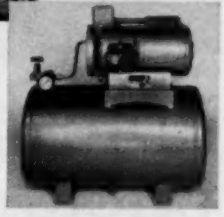
	High	Low	Price As Of 7/15/60
American Meter	52	44	45
Aro Equipment	24 1/4	19	22 5/8
Barry Controls "B"	25 1/2	16 1/4	21 3/8
Belock Instruments	25 3/8	13 1/8	21 1/8
Benrus Watch	7 1/2	5 3/8	6 7/8 Bid 7 1/4 Asked
Breeze Corp.	8 5/8	5 1/8	5 3/8 Bid 5 5/8 Asked
Clark Controller	23 5/8	20	20 1/2
Clarostat Mfg.	16 3/8	9 7/8	11 3/4



ON-THE-SPOT *Oil-less* COMPRESSED AIR FOR INSTRUMENT CONTROL



30 gal. A.S.M.E. Air Tank Outfits 75 and 175 lb. units.



10 gal. Air Tank Outfits. 35, 75, 135 lbs. units mounted on non-code tanks. 75 and 175 lb. units available with A.S.M.E. Code tanks.

For instrument control with compressed air, patented B&G Oil-less Compressors offer outstanding, exclusive advantages.

They deliver air *completely oil-free!* Carbon-graphite piston rings and skirts need no lubrication; bearings are grease-packed and sealed for life. Numerous design and construction features assure dependable delivery of cleaner, cooler, drier air and smoother operation.

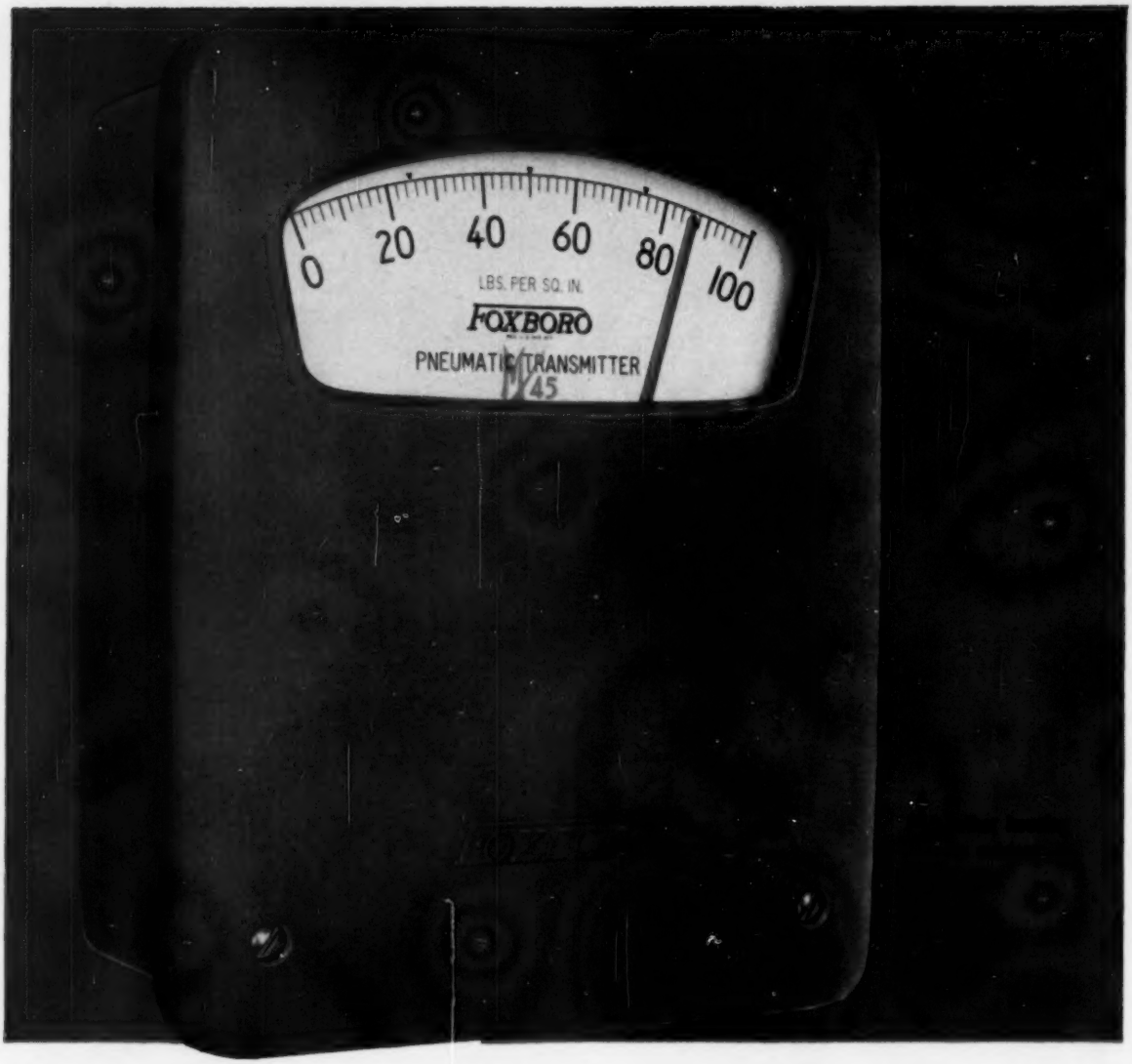
B&G Oil-less Compressors can be located at the site of the control, eliminating long pipe lines which may contaminate the air with dirt and condensation.

58 Models to choose from — tank mounted, portable, motor and gas engine driven.

For complete information on B&G Oil-less Compressors and Vacuum Pumps, send for Catalog GO-1156.

Oil-less
AIR COMPRESSORS
BELL & GOSSETT COMPANY
Dept. GH-43, Morton Grove, Illinois

CIRCLE 32 ON READER-SERVICE CARD



You can use this new Foxboro pneumatic transmitter on six different process measurements

pressure – temperature – liquid level – differential pressure – dew point – flow... all six with guaranteed accuracy of ±½ of 1%

Think of it . . . a universal pneumatic transmitter with matched elements for six different process variables. That's the new Foxboro M/45 pneumatic indicating transmitter.

And with the M/45 you get: *universal* high accuracy-guaranteed at ±½ of 1%; *universal* ambient temperature stability — less than ½ of 1% in 50°F temperature change; *universal* calibration and simplicity of servicing. A remarkable combination of versatility and uniformity in a single instrument.

The new Foxboro M/45 indicating transmitter can extend the benefits of standardization throughout your whole plant operation. Ask your Foxboro field engineer to tell you about it. Or write for Bulletin 13-30. The Foxboro Company, 468 Neponset Ave., Foxboro, Mass.

FOXBORO
REG. U. S. PAT. OFF.

CIRCLE 33 ON READER-SERVICE CARD

AMERICAN STOCK EXCHANGE

continued from page 1245

Clary Corp.	11 1/2	6 3/4	9 1/4
Cubic Corp.	67	48 1/2	57
Dynamics Corp. of Amer.	13 3/4	9 3/4	10 1/4
El-Tronics	1 7/8	1 1/8	1 5/8
Electronics Corp. of Amer.	19 1/2	8 1/8	13
Fairchild Camera & Instrument	200 1/2	110 1/4	173 1/4
General Transistor	33 1/4	18 5/8	27 7/8
Giannini Controls	61 1/2	41 3/4	51 1/4
Globe-Union	34 3/4	25	29
Haseltine Corp.	31 1/2	23	27 1/2
Loral-Electronics	98 1/2	34 5/8	90 1/2
National Research	23 1/8	14 7/8	19 3/8
New Haven Clock	2 7/8	1 1/4	1 5/8
Nuclear Corp. of Amer.	5	2 1/8	4
Philips Electronics, Inc.	46 7/8	31 1/2	39 3/4
Pneumatic Scale	59 3/4	39 1/4	38 Bid 39 3/4 Asked
Polarad Electronics (new)	36 5/8	26 1/2	27 7/8
Servo Corp. of Amer.	24 1/2	14 1/4	18 3/8
Servomechanisms	16	8 1/8	12 1/2
Stathan Instruments Inc.	40 1/4	27 1/8	36
Textron Electronics	18 3/4	11 1/4	14 7/8
Victoreen Instrument Co.	15 1/2	9 3/4	14
Waltham Prec. Instr. Co.	3 1/2	2 3/8	2 5/8

(1) Not Traded - Bid & Asked

These prices and price ranges are given as printed in the Wall Street Journal

Dumont Labs. merged with Fairchild Camera.

OVER THE COUNTER

	Quotation As Of July 15, 1960 Bid	Asked
Aerovox Corp.	12 1/8	12 5/8
Argus Corporation	28	28 3/4
Black Sivalls & Bryson Inc.	11 1/2	12 3/8
Bitel Mc Cullough	26	26 5/8
Electro Instruments	46	48
Electronics Associates	22	23
Erie Resistor Corporation	9 1/2	10
Fisher Governor Co.	16 3/8	17
Foxboro Company (new)	45	47
Hagan Chemicals & Controls	43	44
Industro Transistor	9 5/8	10 1/4
Liquidometer Corp.	15	16
W. L. Maxson	9 3/4	10 1/4
Penn Controls	22 1/4	23
Speer Carbon, Inc.	19 1/2	20 3/8
Sprague Electric	59	60 3/4
Taylor Instruments	70 1/2	74 1/2
Telechrome Mfg. Corp.	12 1/4	13
Telecomputing Corp.	8 7/8	9 1/8
Vitro Corp. of Amer.	12 7/8	13 1/8

Leitz ULTRA-Precision Measuring Microscope

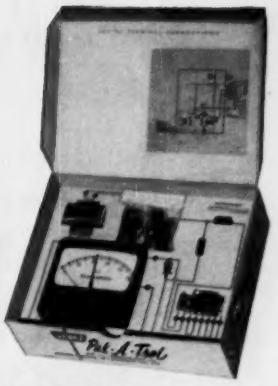
- For critical measurements on miniature parts for the electronic industry.
- Image magnifications between 200x and 600x.
- Reading from optical micrometer between .00005" and .000015".
- Integrated surface illumination.

Request circular 72-111.

OPTO-METRIC TOOLS, INC.
137 IA VARICK STREET, NEW YORK 13, N. Y.

CIRCLE 34 ON READER-SERVICE CARD

NEW AUTOMATIC CONTROLLER KIT



MONITORS AND CONTROLS ANY ELECTRICALLY MEASUREABLE VARIABLE

Use the Pak-A-Trol Kit for controlling or signalling in manufacturing or inspection operations, lab work, prototype development . . . virtually any indicating and control job.

- Low cost . . . just $97.50 in standard DC μa, ma, mv, volt and temperature ranges. Also, AC ranges for motor load.
- Includes 4½" continuous-reading contact meter-relay with adjustable set-point, load relay, power supply components, mounting chassis and hardware.
- Easy to assemble—full instructions provided.
- Operates on 115/230 V AC input (50/60 cycles).

WRITE FOR DATA SHEET NO. 18

api ASSEMBLY PRODUCTS, INC.
Chesterland 10, Ohio

CIRCLE 35 ON READER-SERVICE CARD

NOW . . . Assured Inspection Control for ALL Your Instrumentation!

Quickly . . . easily . . . you can set up Simplified Frequency Inspection Control procedures for all your pressure sensing and indicating instruments, regardless of manufacture . . . assuring superior performance, long life and minimum maintenance.

With the Seegers Standards Simplified Frequency Inspection Control System—patterned for compatability with Mil.-Std.-105A—you get Frequency Inspection Control on a permanent basis to secure maximum production and processing instrument life. There's no need for costly over or under inspection of instrumentation . . . no groping in the dark for an indexing system.

The "packaged" Seegers Standards Simplified Frequency Inspection Control System gives realistic recommendations for the number of Precision Test Gauges per pressure required . . . and the frequency of inspection necessary.

WRITE TODAY . . . Your letterhead request brings the complete story.

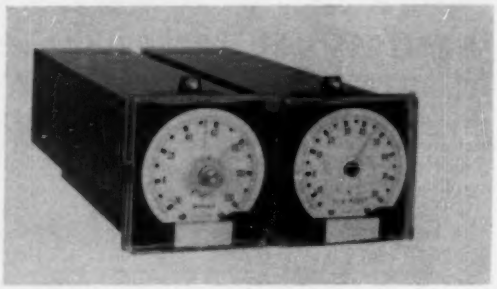
SEEGERS INSTRUMENT COMPANY, INC.
501 West Main Street Barrington, Illinois

CIRCLE 36 ON READER-SERVICE CARD

NEW APPLICATIONS

Weather Bureau Hygrothermometer

WATERBURY, CONN.—U. S. Weather Bureau will install hygrothermometer systems at 170 Weather Bureau stations throughout the United States, with many installations already computed. At those stations where installation and activation of the system have been completed,



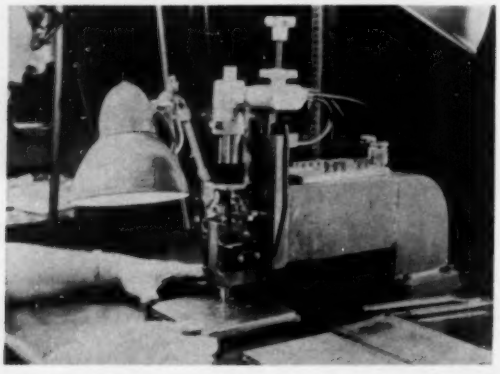
temperatures, as indicated by the hygrothermometer system, are now part of that station's official observation. The observation is disseminated hourly by teletype.

Bristol Series 663 a-c bridge Dynamaster instruments are used as ambient and dew-point temperature indicators in the Weather Bureau's hygrothermometer system. It consists of sensing elements in a thermal shield at the measuring point, and the dew-point and temperature indicators in the observation station.

FOR MORE INFORMATION CIRCLE 228 ON READER-SERVICE CARD

Semi-automatic Drilling

GLENDALE, CALIF.—A new method of precision drilling of circuit boards with semi-automatic equipment had to be developed when Librascope Div. of Gen-



eneral Precision, Inc. (808 Western Ave., Glendale, Calif.) switched over to automated component assembly methods. Holes for mounting components by machine had to be drilled with extreme precision to insure that the machines were able to place each lead in the correct spot.

Since the new equipment was installed, reject rates have dropped drastically, and output of drilled boards per operator has risen.

FOR MORE INFORMATION CIRCLE 229 ON READER-SERVICE CARD

ROYAL McBEE recently installed its 400th Royal Precision LGP-30 computer, at the Continental Oil Co. in Ponca City, Okla.

BENDIX CORP. (Computer Div., 5630 Arbor Vitae St., Los Angeles 45, Calif.) reports another very successful application of its G-15 computer by Stanley Engineering Co. of Muscatine, Iowa, which uses the G-15 in its domestic and operations on the African continent on problems of highway and structural design, hydraulics, power plant, water systems design, etc.

MIDWESTERN INSTRUMENTS (41 and Sheridan Rd., Tulsa 18, Okla.) has received an $800,000 contract from the U. S. Naval Bureau of Ships to build a special-purpose tape recorder, named the AN/UNQ7, for shipboard use in recording sonar signals and other type of signals in the audio range.

BUDD CO.'s Research Lab is using Tatnall RL-6 creep rupture test machines to determine performance of riveted and spot-welded connections at temperatures up to 1800°F which would be encountered by aircraft at speeds of 3800 mph and above at altitudes exceeding 50,000 ft. Budd engineers also are trying to find out the lowest temperatures at which stress relieving will occur within a given time. The test machines are built by Tatnall Measuring Systems Div., The Budd Co., Box 245, Phoenixville, Penna.

MINNEAPOLIS HONEYWELL's Datamatic Div. (Newton Highlands 61, Mass.) is using a Datamatic-1000 data processing computer to produce the "second-generation" all-transistorized Honeywell-800 computer. Estimates are that a minimum of six months in the engineering and design departments alone will be saved through testing the first prototypes of the new computer.

POWERS REGULATOR CO. (3434 Oakton St., Skokie, Ill.) has developed thermostatic water controls with automatic timing devices for a bean sprout grower, Bong Products of Los Angeles, from which 100% labor savings are claimed.

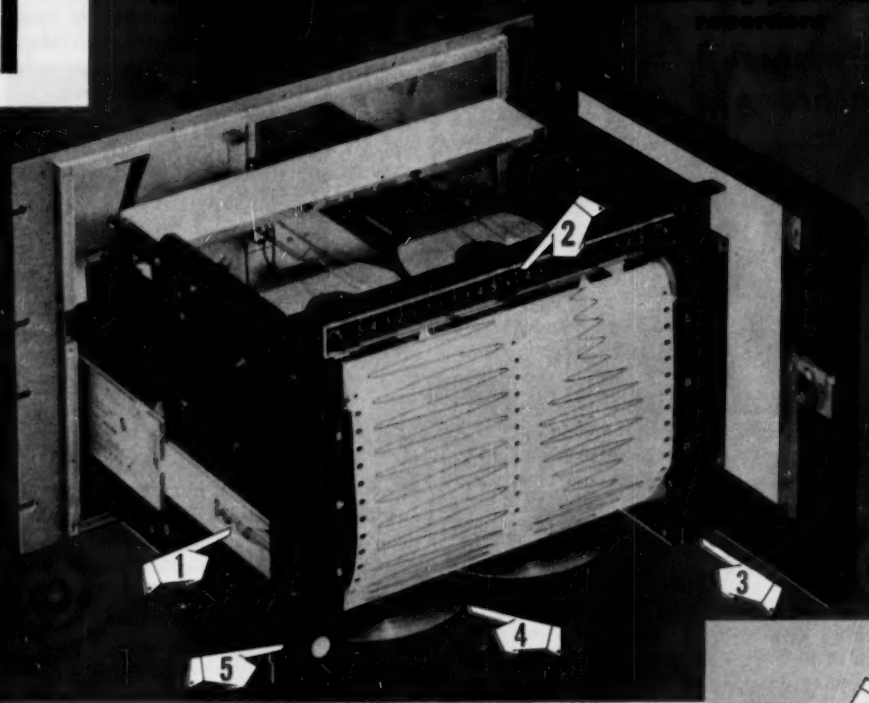
HYDROMATICS Inc., Livingston, N. J., has received two contracts, totalling more than $300,000.00 for Flo-Ball valves to be used on liquid oxygen and fueling trailers.

RADIATION ENGINEERED SERVICES has sold the largest cobalt 60 gamma radiography facility ever built on this continent to Quaker Alloy Casting Co. of Myerstown, Penna.

HIGH PRESSURE ASSOCIATES is a new advisory group, formed by scientists and engineers at a recent meeting under the auspices of Autoclave Enginers, Inc., to offer consulting services and to develop standards in the general field of high pressures. Those interested in these activities should write to its Interim Chairman Barnett F. Dodge, professor of Chemical Engineering, Yale University, New Haven, Conn.

NEW *from* **T/I**

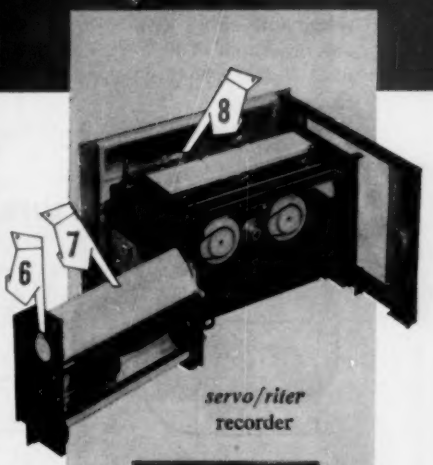
FLUSH-MOUNTING



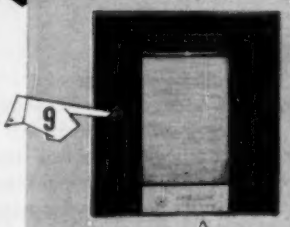
Exclusive convenience features are added to industry-proved recording performance

The NEW flush-mounting *recti/riter* and *servo/riter* recorders (single, dual, and wide channel) contain these operating conveniences, while retaining the reliability and performance characteristics of the proved TI portable recorders.

1. Chassis rolls out and quickly disconnects for maximum ease of installation, adjustment or servicing.
2. Illuminated scales and pointers maintain high readability regardless of room light level.
3. Fingertip releases for chassis roll-out and swing-open chart carriage.
4. Flexible wide range zero adjustment on *recti/riter* recorder. One-half span of calibrated zero suppression provided in each direction.
5. Four-position switch provides off-on, in./hr., standby, and in./min.
6. Chart speed change gears provide 10 standard speeds.
7. Swing-open chart carriage permits easy paper loading and adjustment. Simply lift up to remove carriage. Advanced design eliminates chart drive gear train lash . . . gives better paper position accuracy.
8. Interior design provides flexibility and adequate space to add special functions with ease.
9. Dust tight case has key lock available for limited access. Dimensions: Single recorders—11½″ W., 12⅛″ H., 16″ D.; Dual recorders—16¾″ W., 12⅛″ H., 16″ D.
10. Panel may be easily modified to permit paper feed through bottom of door.



servo/riter recorder



recti/riter recorder

Write for complete information . . .

*A Trademark of Texas Instruments

INSTRUMENTATION GROUP OF

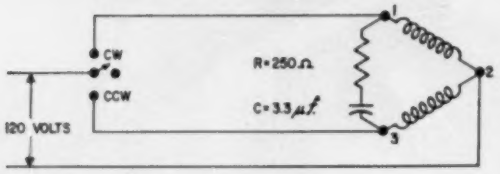
TEXAS INSTRUMENTS
INCORPORATED
GEOSCIENCES & INSTRUMENTATION DIVISION
3609 BUFFALO SPEEDWAY • HOUSTON 6, TEXAS

CIRCLE 37 ON READER-SERVICE CARD

473

BRIEFS

Permanent-Magnet Synchronous Motors

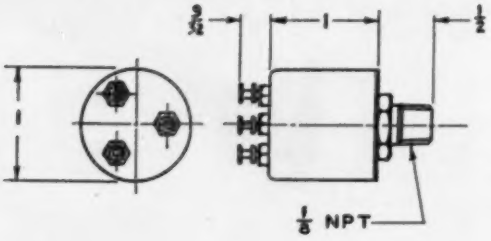


Many electrical and electronic control systems require a small, maintenance-free, constant-speed motor possessing high torque; slow speed; instant starting, stopping and reversing characteristics. The Slo-Syn Synchronous Motor meets these requirements . . . It is an enclosed, permanent magnet type synchronous a-c motor adaptable for a wide variety of control applications.

As a d-c stepping motor the Slo-Syn Synchronous Motor can be adapted for use as incremental positioning device. When used as a control system stepping or "inching" motor, d-c electrical impulses are converted into either 200 or 400 precise increments for one revolution of the motor shaft . . . (*From new* 12-*page Bulletin SS*459, *Superior Electric Co., Bristol, Conn.*)

FOR THIS LITERATURE CIRCLE 230 ON READER-SERVICE CARD

Miniature Pressure Switch



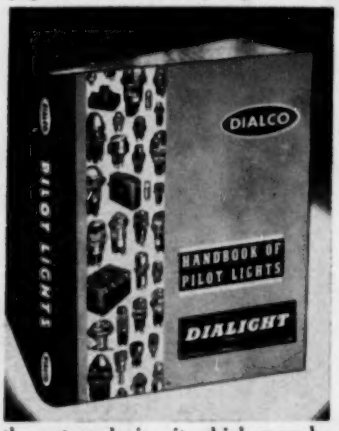
The accurate response of the capsular type element used has been combined with rugged construction to produce a switch which will withstand a shock of 100 G's, yet guarantees a repeatable accuracy of ±0.5% . . . There are no springs, linkages or bearings in these units; only one moving part. This prevents drift of the activation setting due to bearing wear or spring fatigue and maintains extreme accuracy for the entire operating life of the unit . . . .

Design modifications to satisfy specific customer requirements may be had on special order. Modification requests should include all environmental conditions and performance requirements . . . (*From new Specification Flyer, Pamar Electronics Co., Inc., a sub. of Hoke Inc.,* 1 *Tenakill Park, Cresskill, N. J.*)

FOR THIS LITERATURE CIRCLE 231 ON READER-SERVICE CARD

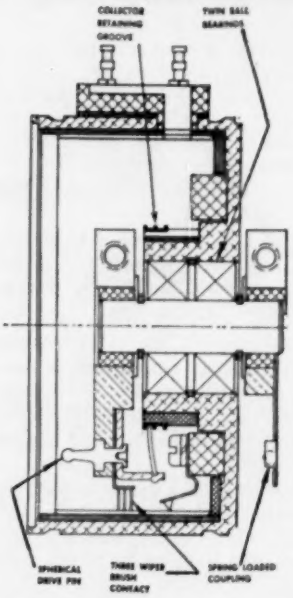
Light Sources for Pilot Lights

Since neon lamps will light with so much resistance in series, they make dependable blown fuse indicators. They are shunted across the fuse and, of course, show no glow as long as the fuse link is intact. When it blows, they glow with certainty regardless of the condition of the external circuit which may be impaired and have relatively high resistance. In a similar way neon glow lamps are used across themostatically operated switches and indicate the open circuit condition of the thermostat which will coincide with some selected temperature being reached . . . (*From new* 256-*page "Handbook of Pilot Lights," plus* 8-*page Index, Dialight Corp.,* 60 *Stewart Ave., Brooklyn* 37, *N. Y.—Circle Card for Application Blank.*)



FOR APPLICATION BLANK CIRCLE 232 ON CARD

Ball Bearing Precision Pot



Independent Linearity: 0.5% is standard; 0.2% on order.

Dual, stainless steel, instrument precision ball bearings are used to insure mimimum radial shaft play and improved linearity.

Independent linearity is the deviation in percent of the total measured resistance at any point, from the best straight line drawn through the resistance vs rotation curve. The slope and position of the line can be adjusted to make these deviations a minimum . . . (*From new* 28-*page bulletin, DeJur-Amsco Corp.,* 45-01 *Northern Blvd., Long Island City* 1, *N. Y.*)

FOR THIS LITERATURE CIRCLE 233 ON READER-SERVICE CARD

CIRCLE 38 ON READER-SERVICE CARD →

this is the Brush Mark II... anyone can plug it in put it in writing anywhere

There is no direct writing recorder on the market that approaches the compact Mark II in sheer usefulness. It is a completely integrated engineering tool that can be operated by anyone . . . in the shop or in the field . . . for countless research or design requirements. Every function necessary for uniform, crisp, easily reproduced readouts is "built-in". The Mark II gives you two analog channels plus two event markers; 4 chart speeds; DC to 100 cps response with 40 mm amplitude; 10 mv/mm sensitivity; high input impedance. Immediate shipment from stock. Call, write or wire for complete details.

brush INSTRUMENTS
DIVISION OF
37TH AND PERKINS CLEVITE CORPORATION CLEVELAND 14, OHIO

for direct writing recording systems no one is as qualified as Brush

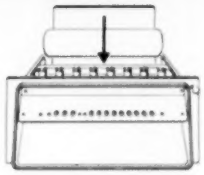
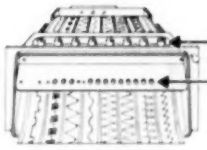
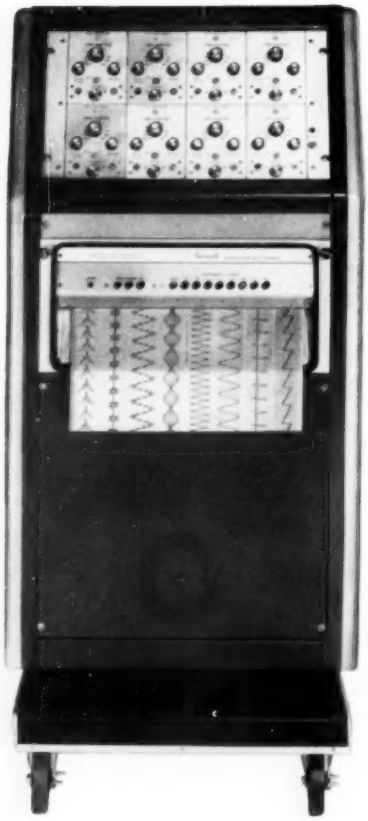


Chart paper loads from top



Trace contrast control

Simple pushbutton speed selection



Why? Simply because Brush recording systems such as this 6-8 channel unit incorporate all of the known refinements in the art of recording by direct writing. No comparable system in existence today is as compact . . . as simplified . . . as reliable . . . as versatile. Note slide-mounted oscillograph and interchangeable "plug-in" signal conditioners that provide four vital functions in addition to amplification: high input impedance, zero suppression, attenuation and calibration.

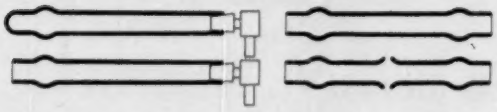
Instantaneous rectilinear presentation gives clear, uniform and reproducible traces for precise readout of telemetry, computer, ground control and other data gathering operations. Further, this functionally designed system has a "pull-out" horizontal writing table for convenient annotation and reading . . . without turning off the recorder! Check these and many other advanced features for yourself and you'll see why *no one* is as qualified as Brush. Call, write or wire for complete details.

brush INSTRUMENTS

DIVISION OF

37TH AND PERKINS **CLEVITE** CORPORATION CLEVELAND 14, OHIO

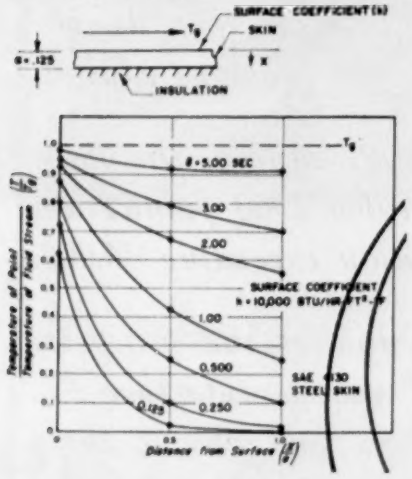
Hose Connections in Glass Tubing



Glass hose connections are commercially available, but substitutes can be readily made. For a common size of rubber hose, cut a piece of 8 or 9 mm glass tubing about 4 inches long. Fuse one end shut, and close to it form a ridge by heating a narrow band and blowing. Blow open and fire polish the closed end. Transfer the blow hose to this end and repeat the operation already described. Cut through at the middle point and flare both ends, making two hose connections. The steps are shown in Fig. 18 . . . (*From new 57-page "Manual of Simplified Glass-blowing," Bethlehem Apparatus Co., Inc., Hellertown, Pa.*)

FOR THIS LITERATURE CIRCLE 234 ON READER-SERVICE CARD

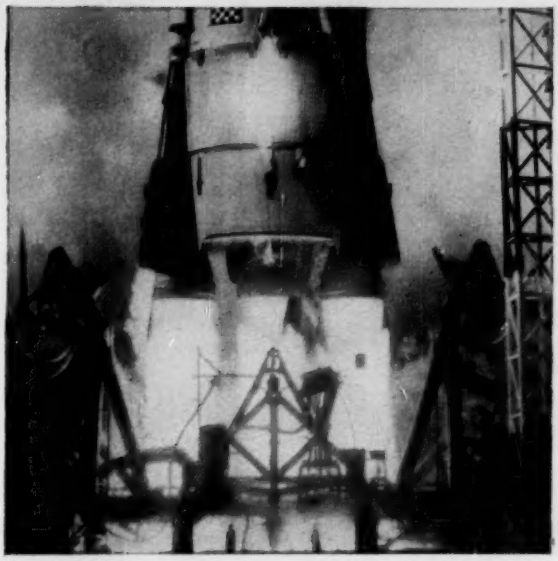
In-Wall Temperature Sensors

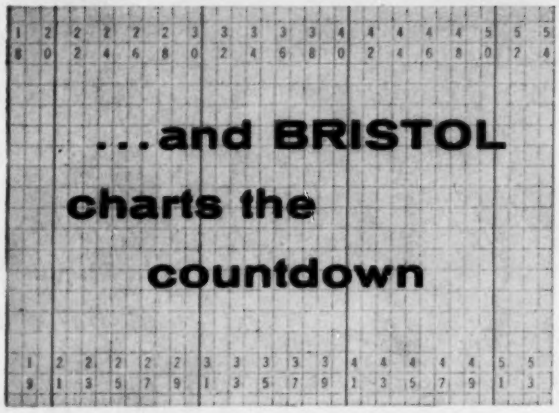


The *Delta* couple makes possible the measurement of temperatures at precise in-wall locations in this section . . . Heat transfer studies show that the time-temperature-depth history under transient heating conditions is adequately determined by the temperature distribution in the 50% of wall thickness nearest the heat input surface, plus a single measurement at the opposite unexposed surface. The standard line of Delta-Couple provides measurements in accordance with this criterion . . . . By a "weld-nugget" technique, ribbon junctions are embedded in the sensor body at selected depths. The junction location is determined by X-ray measurements to ±0.003" or closer. The sensor bodies are selected from materials that are weldable and thermally compatible with the wall or parent material . . . (*From new 4-page Bulletin ATL-903 and 21-page Bulletin ATL-905, Advanced Technology Labs., Div. of American-Standard, 369 Whisman Road, Mountain View, Calif.*)

FOR THIS LITERATURE CIRCLE 235 ON READER-SERVICE CARD

ATLAS AWAY!





Bristol charts (sample above) in specially built "time and event recorders" at Vandenberg Air Force Base tell engineers vital facts about the critical moments in the countdown and first few minutes of flight of each Atlas missile.

Printed for Convair (Astronautics) Division of General Dynamics Corporation, prime contractor for the Atlas missile, these charts are just one example of the hundreds of "specials" turned out every year at Bristol chart printing facilities—one of the largest, most complete plants of its kind in the country.

Strip charts up to 32" across, circular charts to 12" diameter can be handled. Standard chart papers of highest quality are available. Or, Bristol can print on a wide variety of special papers, such as papers for metallic marking, foil-type laminates, card stock, heat- and pressure-sensitive, carbon-coated, or photo-sensitive oscillographic papers.

Get in touch with Bristol if you're designing a special recording instrument. An entire special chart engineering service is at your disposal. Or, for more information about this service, write for Bulletin Y1906. The Bristol Company, 154 Bristol Road, Waterbury 20, Conn. 9.29.

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AUTOMATIC CONTROLLING, RECORDING AND TELEMETERING INSTRUMENTS

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←CIRCLE 39 ON READER-SERVICE CARD

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MOST COMPACT • MOST ECONOMICAL

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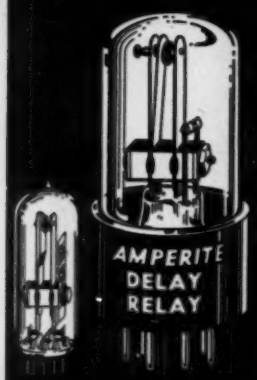


Thermostatic DELAY RELAYS

2 to 180 Seconds

Actuated by a heater, they operate on A.C., D.C., or Pulsating Current.

Hermetically sealed. Not affected by altitude, moisture, or climate changes.

SPST only—normally open or closed.

Compensated for ambient temperature changes from —55° to + 70° C. Heaters consume approximately 2 W. and may be operated continuously. The units are **rugged, explosion-proof, long-lived, and—inexpensive!**

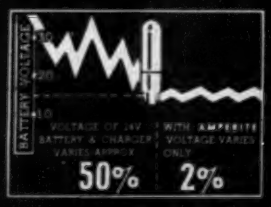
Also — **Amperite Differential Relays:** Used for automatic overload, under-voltage or under-current protection.

TYPES: Standard Radio Octal, and 9-Pin Miniature . . . **List Price, $4.00.** Standard Delays

PROBLEM? Send for Bulletin No. TR-81

BALLAST REGULATORS

Amperite Regulators are designed to keep the current in a circuit **automatically regulated** at a definite value (for example, 0.5 amp.) . . . For currents of 60 ma. to 5 amps. Operate on A.C. D.C., or Pulsating Current.



Hermetically sealed, they are not affected by changes in altitude, ambient temperature (—55° to + 90° C.), or humidity . . . Rugged, light, compact, most inexpensive . . . **List Price, $3.00.**

Write for 4-page Technical Bulletin No. AB-51

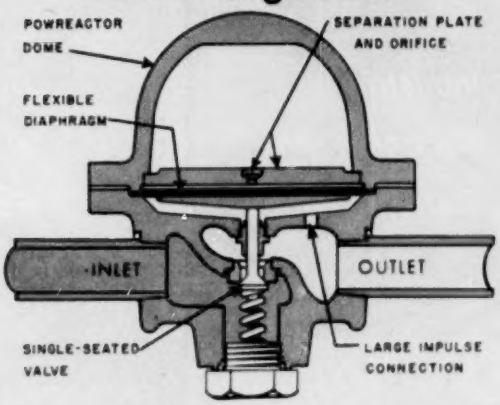
AMPERITE CO. Inc., 561 Broadway, New York 12, N. Y.

Telephone: CAnal 6-1446

In Canada: Atlas Radio Corp., Ltd., 50 Wingold Ave., Toronto 10

FOR BULLETIN TR-81 CIRCLE 41 ON READER-SERVICE CARD
FOR BULLETIN AB-51 CIRCLE 42 ON READER-SERVICE CARD

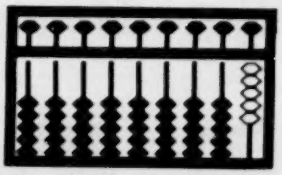
Dome Regulators



Grove regulators operate under the simple basic law governing gas pressures and volume within closed vessels or chambers. Briefly stated, this law provides that "the pressure of an enclosed gas varies inversely as its volume." . . . The Grove Pressure Regulator is of the balanced pressure type—deriving its powerful equalizing force from the large volume Powreactor Dome or loading chamber, which is charged with a compressible gas or air, at a pressure equal to the reduced pressure desired . . . With the slightest drop in delivered pressure, the pressure charge in the dome instantly forces the valve open, allowing a measured volume of flow to pass, thereby maintaining the delivery at a constant pressure . . . (*From new 16-page Bulletin 123A-R2, Grove Valve and Regulator Co., 6529 Hollis St., Oakland 8, Calif.*)

FOR THIS LITERATURE CIRCLE 236 ON READER-SERVICE CARD

How to Use an Abacus



The abacus is basically a digital decade counter using a standard 0 through 9 number system. Reading from right to left as in conventional math, the vertical columns of beads represent units, tens, hundreds, and so on. The abacus has a cross bar dividing all vertical columns into groups of one bead at the top, and five beads at the bottom. Each bead in the bottom section has a value of 1, and each bead at the top has a value of 5. Each vertical column represents a numerical place just as in conventional math. Beads in the right hand column have a value in units, each of the five lower beads representing 1 unit, and the single bead at the top representing 5 units. In the columns to the left the values would be respectively tens, hundreds, thousands, and so on . . . (*From new 12-page brochure describing Minichron Solid-State program timers, Jordan Electronics Div. of the Victoreen Instrument Co., 3025 W. Mission Rd., Alhambra, Calif.*)

FOR THIS LITERATURE CIRCLE 237 ON READER-SERVICE CARD

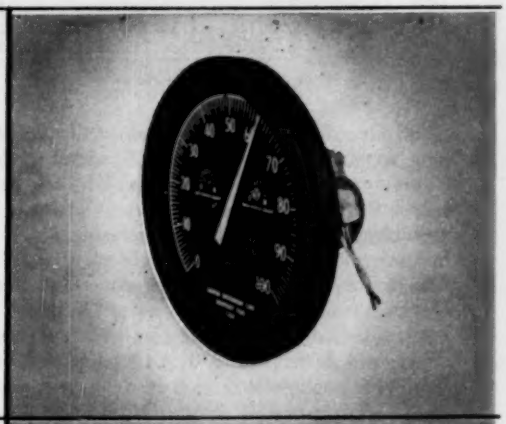
3 NEW DIFFERENTIAL PRESSURE SWITCHES

for FLOW, LIQUID LEVEL and DIFFERENTIAL PRESSURE APPLICATIONS

activated by BARTON RUPTURE-PROOF METER BODIES

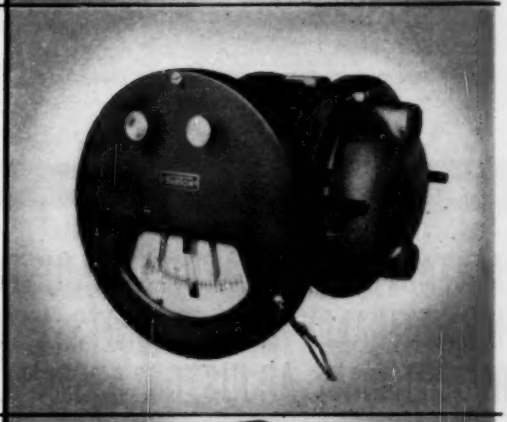
MODEL 258
INDICATING DIFFERENTIAL PRESSURE SWITCH

The Model 258 indicating switch employs vibration and shock resistant milliswitches to energize alarm circuits when predetermined limits of differential pressure, flow or liquid level are exceeded. The 270° pointer rotation provides maximum readability and the direct-set switch contacts are adjustable over the entire scale. Scales are available for direct reading of differential pressure, flow or liquid level. The instrument is actuated by the Model 224 Rupture-Proof Differential Pressure Unit, and incorporates all of the advance features of this unit. The Model 258 was designed to meet industry's need for a highly readable and sensitive switch, suitable for high static pressures, but responsive to small differential pressures. For further information request Bulletin 258-1.



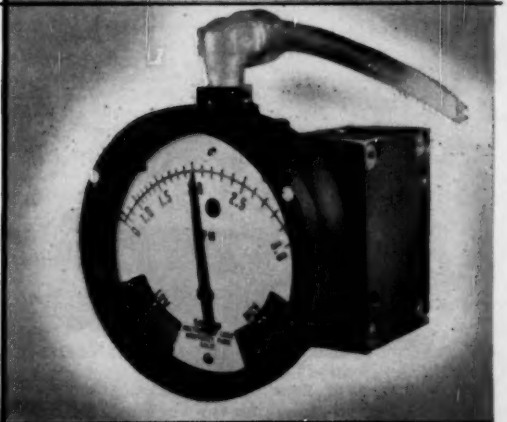
MODEL 250
INDICATING DIFFERENTIAL PRESSURE SWITCH

The Model 250 measures and indicates differential pressure, flow and liquid level and energizes alarm circuits when measurement exceeds predetermined limits. This instrument is the direct-set type with contact points externally adjustable over the entire scale. Contacts can be set for high or low, double high or double low operation. The 250 employs a large, target-type, indicating pointer and red contact set pointers. The Model 199 Rupture-Proof Differential Pressure Unit is used to actuate the indicating pointer and one or two magnetically operated mercury switches. Scales are available for direct reading of flow rate, differential pressure, or liquid level. For further information request Bulletin 250-1.



MODEL 251
INDICATING DIFFERENTIAL PRESSURE SWITCH

The Model 251 indicating switch employs shock resistant milliswitches to energize alarm circuits when predetermined limits of differential pressure, flow or liquid level are exceeded. The Model 224 Rupture-Proof Differential Pressure Unit is used to actuate the indicating pointer and one or two milliswitches. Switch contacts are the direct-set type, adjustable over the entire scale. The indicating pointer traverses a 120° arc over the 3½" round dial and is graduated uniformly for differential pressure or liquid level measurement. Square root scales are provided for direct reading of flow rate and special scales can be furnished for indicating the quantity of fluid in tanks. The Model 251 is qualified for shock and vibration conditions under the provisions of MIL-S-901, and is used in critical applications by the Armed Services. For further information request Bulletin 251-1.



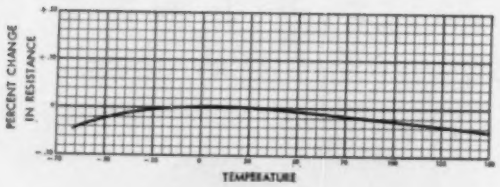
BARTON

580 MONTEREY PASS ROAD, MONTEREY PARK, CALIFORNIA

For Bulletin 258-1—Circle 43 For Bulletin 250-1—Circle 44 For Bulletin 251-1—Circle 45

IGS **BRIEFS**

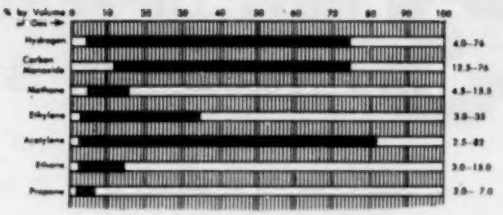
800-Ohm Resistor Alloy



Introduced under the trade name "Chromel-R," the new material consists of 74% nickel and 20% chromium plus small percentages of other alloying elements which have been found to produce certain metallurgical changes during processing which greatly improve the electrical characteristics of the finished fine drawn wire . . . Specific properties include an electrical resistivity of 800-ohms/cmf at 20° C. and a low controlled temperature coefficient of resistance guaranteed to be within 0 ±10 part/ million/° C. (±0.00001 ohm/ohm/° C.) over the operating range from −65° to +150° C . . . (*From new 2-page Release H-105, Hoskins Mfg. Co., 4445 Lawton Ave., Detroit 8, Mich.*)

FOR THIS LITERATURE CIRCLE 238 ON READER-SERVICE CARD

Gas Detectors



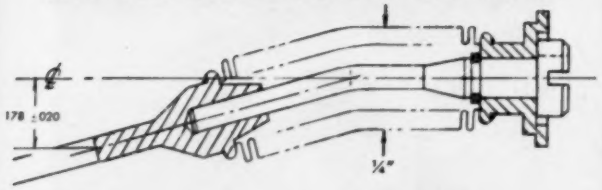
All Houston Instrument gas detectors use the hot wire platinum element for detection. A current is applied to the element which adsorbs the gas and actually burns it on the surface without a flame. The heat generated changes the resistance value of the bridge producing an accurate meter reading, proportional to the quantity of gas present.

Indication is calibrated in percent of the Lower Explosive Limit, (the least proportion of a subject gas in an air mixture which, when exposed to a spark, flame or heat may possibly explode), of the gas under consideration. As an example, methane (most common gas detection reference used) when mixed with air to the volume percentage of 4½%, is at the Lower Explosive Limit . . . (*From new 4-page Bulletin "Series 500 Gas Detectors", Houston Instrument Corp., Box 22234, Houston 27, Tex.*)

FOR THIS LITERATURE CIRCLE 239 ON READER-SERVICE CARD

SEALED ADJUSTOR

MAINTAIN VACUUM WHILE ADJUSTING HERMETICALLY SEALED UNITS WITH ROBERTSHAW ADJUSTOR ASSEMBLY

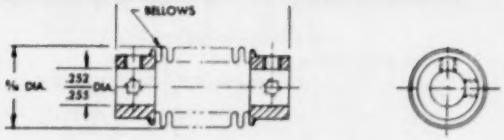


Now . . . adjust or recalibrate hermetically sealed instruments without breaking the vacuum. Robertshaw Adjustor Assemblies permit 360° adjustment. Heat treated steel shaft inside miniature seamless metallic bellows transmits torque from external source to internal mechanism. Leak tested on mass spectrometer. Unit shown is a zero adjustor for an aircraft instrument. Available as custom units with bellows as small as ⅛" O.D. **WRITE FOR ENGINEERING DATA SHEET F-108!**

CIRCLE 46 ON READER-SERVICE CARD

FLEXIBLE COUPLING

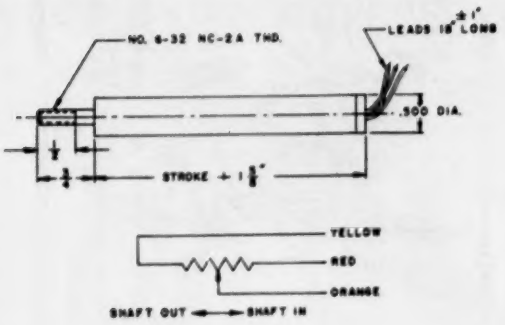
ELIMINATE BACKLASH, END-PLAY! ABSORB VIBRATION, SHOCK WITH ROBERTSHAW FLEXIBLE COUPLINGS



Servomechanisms, instruments and similar drive and control systems are the big users of these small, flexible units. Ideal for guarding against misalignment friction and bearing wear problems. Save space and weight. Cut down noise. Simplified design utilizes seamless metallic bellows, in choice of several metals, connected to two hubs. Sizes from 1⅛" O.D. Stock sizes accommodate shafts from ⅛" to ½". Other sizes custom-engineered. **WRITE FOR DATA SHEET F-808!**

CIRCLE 47 ON READER-SERVICE CARD

Potentiometer Transducers

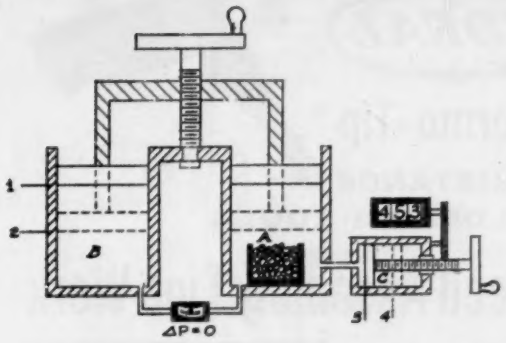


Model 3-120 wirewound, linear motion feedback potentiometers, for operation in ambient temperatures to 500°F, are extremely rugged instruments, designed for use with both hydraulic and electrical actuators . . . Only ½" in diameter, they have unusually high resolution with linearities to 0.1%.

Pressure transducers include the Model 2-28 Secondary Pressure Standard and the Tavis DeCeducer pressure transducer line . . . (*From new 4-page Form S11-WJ, and 2-page Bulletin* 3012.1, *Edcliff Instruments,* 1711 *South Mountain Ave., Monrovia, Calif.*)

FOR THIS LITERATURE CIRCLE 240 ON READER-SERVICE CARD

True Volume Measurement



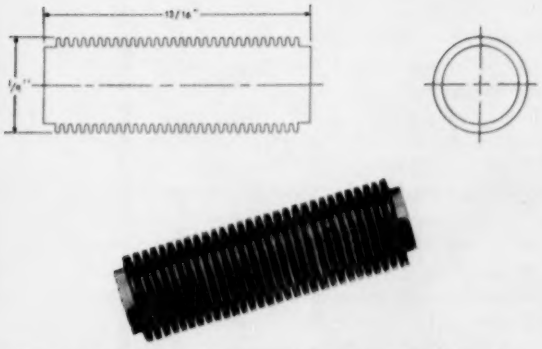
Model 200 Air Operated Pycnometer is based on the principle that two closed systems of air at the same pressure and temperature will have identical specific volumes . . . It is only necessary to insert a sample of the material to be measured into a sample container . . .

There are two identical equal volume chambers A and B stroked by pistons through a fixed distance. A third cylinder, C, is connected to cylinder, A, and has a calibrated stroke so that for any movement of its piston a counter registers the proportionate volume displaced . . . (*From new 4-page news release, Houston Instrument Corp., Box* 22234, *Houston* 27, *Tex.*)

FOR THIS LITERATURE CIRCLE 241 ON READER-SERVICE CARD

MINIATURE BELLOWS

SAVE SPACE AND WEIGHT WITH RUGGED, MINIATURE ROBERTSHAW FORMFLEX* BELLOWS



Now . . . hydraulically formed seamless metallic bellows as small as ⅛" O.D.! These miniature Formflex units, along with ¼" and 5/16" O.D. sizes, permit further miniaturization in aircraft, missiles, instruments and other equipment. All sizes are available in a wide range of metals to provide the desired strength and performance characteristics. Ideal in assemblies that react to or compensate for pressure and temperature changes. *Custom*-engineered in any quantity you may require.

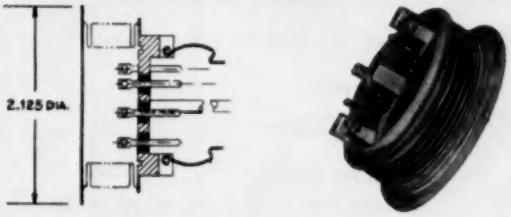
WRITE FOR BULLETIN F-108!

*Registration pending

CIRCLE 48 ON READER-SERVICE CARD

FLUID EXPANSION CAPSULE

THERMAL EXPANSION OF OIL CONTROLLED BY SPACE-SAVING ROBERTSHAW FORMSET® BELLOWS



A low spring rate and a large stroke per unit of length, provided by a special Robertshaw Metallic Bellows called Formset, made possible this expansion capsule used in airborne gyroscopes. This assembly absorbs the thermal expansion of the oil which encases the gyroscope. Low spring rate in the bellows permits low pressure in the gyro. Space savings of up to 90% in bellows length can be achieved with Formset Bellows. Custom-engineered for instruments, transformers, relays and other applications using any fluid. **WRITE FOR ENGINEERING DATA SHEET F-108!**

Robertshaw

BRIDGEPORT
THERMOSTAT DIVISION
ROBERTSHAW-FULTON CONTROLS CO.
Milford, Conn.

CIRCLE 49 ON READER-SERVICE CARD

IDEAL

Thermo-Tip®

RESISTANCE SOLDERING TOOLS

NEW easier-to-handle "Pistol-Grip" Style

Speed Assembly Line Work

up to

42%*

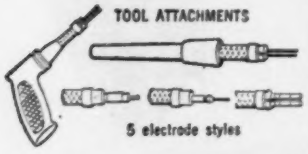
greater reliability for soldering pin-type plugs, aircraft connectors, wire-to-wire, terminals, instruments, printed circuits, electronic systems and parts.

- higher soldering speed reduces costs
- higher-quality connections — fewer rejects
- better, more accurate work on miniaturized assemblies
- light, easy-to-handle — women can use all day without fatigue
- entirely safe, heat only on contact — no operator burns

*Proved by on-the-job comparisons . . . ask for Bulletin C217

COMPLETE LINE OF EQUIPMENT FOR ALL NEEDS

TOOL ATTACHMENTS



5 electrode styles

3 POWER UNIT SIZES

500-Watt 250-Watt 125-Watt

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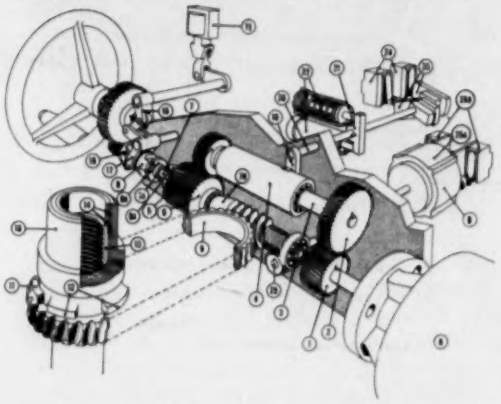
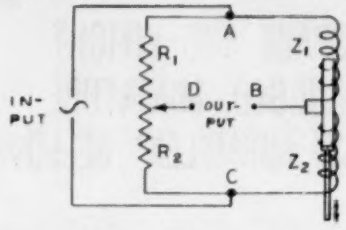
Motorized Valve Actuator



Utilizing a double reduction helical gear drive, the Helitork Actuator provides the widest speed range currently available with a self-locking worm gear set for all ratios. Ratio (speed) variations are accomplished by changing the helical gears only . . . Torque Control Switch is based on the principle of helical gearing producing end thrust along the axis of rotation in addition to normal radial driving force. This permits light, sensitive torque springs to control valve seating to exact pre-determined values . . . Helitork's Automatic Drive Diverter completely eliminates valve stem overtravel, without the use of brakes or friction clutches . . . (*From new 8-page Bulletin* 5911, *Helitork, Div. of the Earle Gear & Machine Co.,* 4707 *Stenton Ave., Phila.* 44, *Pa.*)

FOR THIS LITERATURE CIRCLE 242 ON READER-SERVICE CARD

Displacement Transducers



Electromagnetic linear displacement transducers can be divided into two basic types: variable reluctance type transducers and linear variable differential transformers.

The Kavlico variable reluctance type transducers . . . basically, are constructed of two coils and a slug . . . The slug is composed of two rods of different diameter. The large diameter portion is made of magnetic steel and is approximately half as long as the total length of the coils. Attached to the magnetic portion is a smaller diameter extension which is made of non-magnetic steel and is attached to the moving body . . .

The variable reluctance type transducer is operated in a bridge. The bridge is excited with an a-c signal across 'A'—'C'. When the magnetic portion of the slug is at the center of the transducer, an equal portion of the slug extends into each coil . . . (*From new 42-page binder, Vinson Mfg. Co., Inc.,* 8044 *Woodley Ave., Van Nuys, Calif.*)

FOR THIS LITERATURE CIRLCE 243 ON READER-SERVICE CARD

ANNIN VALVES

"STAGE CENTER" AT THE 15TH ANNUAL INSTRUMENT-AUTOMATION SHOW

Booth 613

(front and center on the main floor)

...the proven answer to complex fluid control problems in the process industries and missile ground support

Always the center of attraction where the newest control valve concepts are sought, ANNIN brings to this year's Instrument-Automation Show new designs... new solutions... to complex control problems for industry and the military. On display—an improved standard valve line augmented by custom-built electro-hydraulic and pneumatic-hydraulic actuators. For missile and space vehicle ground support, Annin presents for the first time a self-draining valve for storable propellants, and a new vacuum jacketed valve for the control of liquid hydrogen. Check ANNIN first...and discover why no other line of valves and actuators offers so much in design and performance features.

Annin
VALVES

THE ANNIN COMPANY
1040 SOUTH VAIL AVENUE
MONTEBELLO, CALIFORNIA

CIRCLE 51 ON READER-SERVICE CARD

What's YOUR Portable Power Problem?

BURGESS has more than 5000 battery types to choose from:

ZINC-CARBON

NICKEL-CADMIUM MERCURY

WATER-ACTIVATED

each with the highest measure of uniform dependability! This is why 2 of 3 electronic engineers specify

BURGESS BATTERIES

BURGESS

IS THE MOST COMPLETE ONE-SOURCE LINE OF *Portable Power!*

EXCLUSIVE WAFER CELL CONSTRUCTION

. . . offers compactness, long shelf life, exceptional service life. A 30% increase in battery life at no increase in size.

TRANSISTOR ACTIVATORS

Burgess Activator Batteries for transistor circuits are smaller and more compact in size! Yet they deliver 30% more power because of the patented "Wafer-Cell" construction! Burgess Activators give you compact power, uniform performance, longer shelf life . . . all combined with modern packaging.

RESERVE BATTERIES

High energy output in a compact power source. Can be stored dry for years! Activated only when immersed in water. No handling of dangerous electrolyte, no spilling or leaking! Wide range of efficient operating temperatures. Designed for your specific applications.

MERCURY ACTIVATORS

Burgess constructional features provide *uniform quality* and *dependable service!* Burgess *exclusive* patents offer sealed-in-steel protection, wide temperature range efficiency, controlled venting, patented inner cell connector, and flat discharge curve.

SEALED NICKEL-CADMIUM BATTERIES

A secondary rechargeable battery system which delivers high energy output from a small package! Hermetically sealed-in-steel cells eliminate annoying maintenance and addition of liquids. Can be recharged many times, by trickle or quick charge, for long lasting economical power!

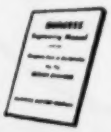
Check with your Burgess Distributor for complete local stocks of fresh BURGESS BATTERIES! Or your distributor can order from Burgess the special battery needed for your specific application!

FREE DESIGN SERVICE

For special applications, skilled Burgess Engineers offer you a FREE battery design service. Burgess will manufacture the exact battery to fit your needs, regardless of quantity required.

NEW ENGINEERING MANUAL

New 100-page dry battery handbook now available! Engineers engaged in the design of battery-powered equipment are invited to write to Burgess Battery Company, Dept. ICS Freeport, Ill., to secure a copy. Others may buy the manual for $1.00.



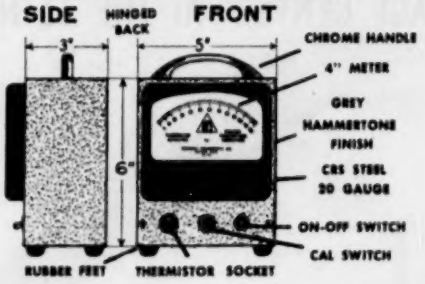
BURGESS BATTERY COMPANY

DIVISION OF SERVEL, INC.

FREEPORT, ILLINOIS

CIRCLE 52 ON READER-SERVICE CARD

Remote-Reading Electronic Thermometers



Electronic, remote reading thermometers are thermistor actuated. Operating Temperatures are 40°F to 140°F. Probe is made with 11 ft., No. 22, vinyl-covered leads. Specifications for Vibration, Shock, and Humidity are listed in the American Standard Manual . . . (*From 8-page condensed catalog, Marshall Instruments Inc.,* 14203 *Bessemer St., Van Nuys, Calif.*)

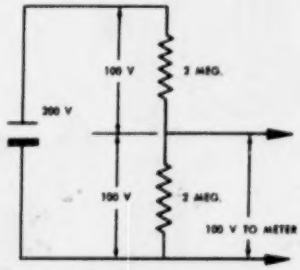
FOR THIS LITERATURE CIRCLE 244 ON READER-SERVICE CARD

Signal Commutation

This new low-level Radiplex system directly multiplexes up to 96 transducer inputs, each at a rate of 312.5 samples per second. Versatile sampling programming capability provides for exchanging number of channels for sampling rate . . . Internally the Radiplex 89 consists of six sections, each with 8-input channel capability. At a 24 kc word rate each section is independently driven at a 4000 cps rate. This can be subdivided among the 8 channels in groups of 1, 2, 4, and 8 thereby providing channel sampling rates of 4000, 2000, 1000, and 500 cps respectively . . . (*From new 4-page bulletin "Radiplex 89" Radiation Incorporated, P.O. Drawer 37, Melbourne, Fla.*)

FOR THIS LITERATURE CIRCLE 245 ON READER-SERVICE CARD

Digital Voltmeters



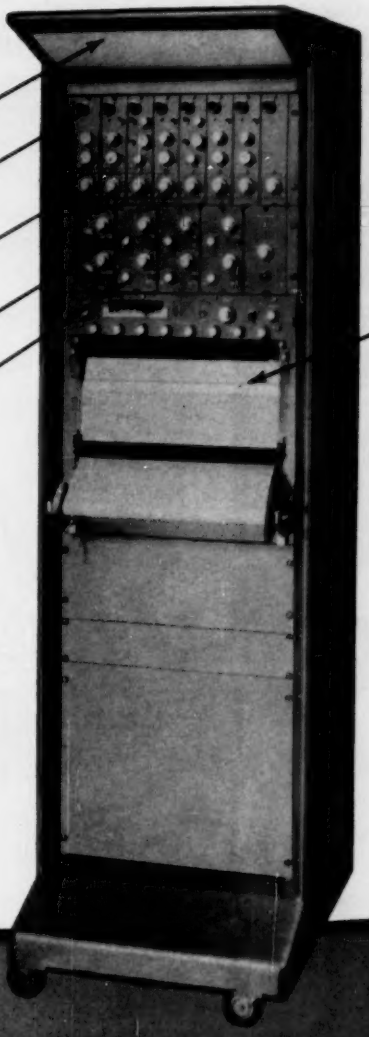
The Franklin Series 500 instruments represent a significant advance in the art digital measuring instrument design . . . On all d-c ranges, except 0-1200 V, the input resistance approaches infinity. By means of a simple front-panel adjustment the effective input resistance can be made infinite. Coupled with an absolute accuracy of 0.1%, precision voltage measurements can be obtained quickly . . . (*From new 4-page Bulletin 309, Franklin Electronics, Inc., Bridgeport, Penna.*)

FOR THIS LITERATURE CIRCLE 246 ON READER-SERVICE CARD

OFFNER
ALL TRANSISTOR

TYPE R DYNOGRAPH

the most versatile . . . most sensitive direct writing unit available



Illuminated canopy

Type 9800 series input couplers provide all input, control and balance functions. Input available both front and rear.

Type 481 Preamplifier provides sensitivities from one microvolt to 5 volts per mm.

Type 482 power amplifiers—may be used without preamplifiers for up to 10 mv/cm sensitivity

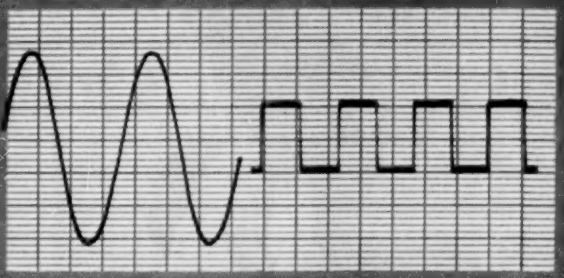
Zero suppression control

504-A paper drive—speeds from 1 to 250 mm/sec. Electrical speed shift 1 to 250 mm per minute available. Zero weave high precision drive, 850 ft. capacity (heat or electric) 1500 ft. (ink). Front loading, with full unobstructed record visible from front.

Combining all these features...

- *stable d-c sensitivity of one microvolt per mm*
- *true differential input*
- *high input impedance*
- *response to beyond 150 cps.*
- *reluctance, differential transformer, strain gage with a-c or d-c excitation, thermocouples, etc., used with all preamplifiers*
- *deflection time less than 1.5 milliseconds (2.5 ms with preamplifiers)*
- *fixed precision calibration*
- *instant warm-up*
- *precision source for d-c and 400 cycle excitation, self-contained*
- *zero suppression, twenty times full scale, both directions*

FULL SCALE, UNRETOUCHED CHARTS PRODUCED ON THE TYPE R DYNOGRAPH



EXTREME SENSITIVITY

10 Microvolt RMS Sine Wave — **Ten Microvolt D-C Square Wave**

Four recording media. Heat or electric rectilinear—ink or electric curvilinear. Readily convertible.

CIRCLE 83 ON READER-SERVICE CARD

All these features . . . plus 8 channels in only 30" of rack space. Whatever your application for direct writing records . . . you should investigate the ability of the Offner Type R Dynograph to do the job *better* and more *simply*. Using transistor circuits* developed and tested for over three years in thousands of channels of Offner equipment, the Type R Dynograph has already proved its superiority in practically every respect to any other direct writing oscillograph. Write on your company letterhead for literature giving details and specifications.

*Patents granted and pending

OFFNER ELECTRONICS INC.

3910 River Road, Schiller Park, Ill.

(Suburb of Chicago)

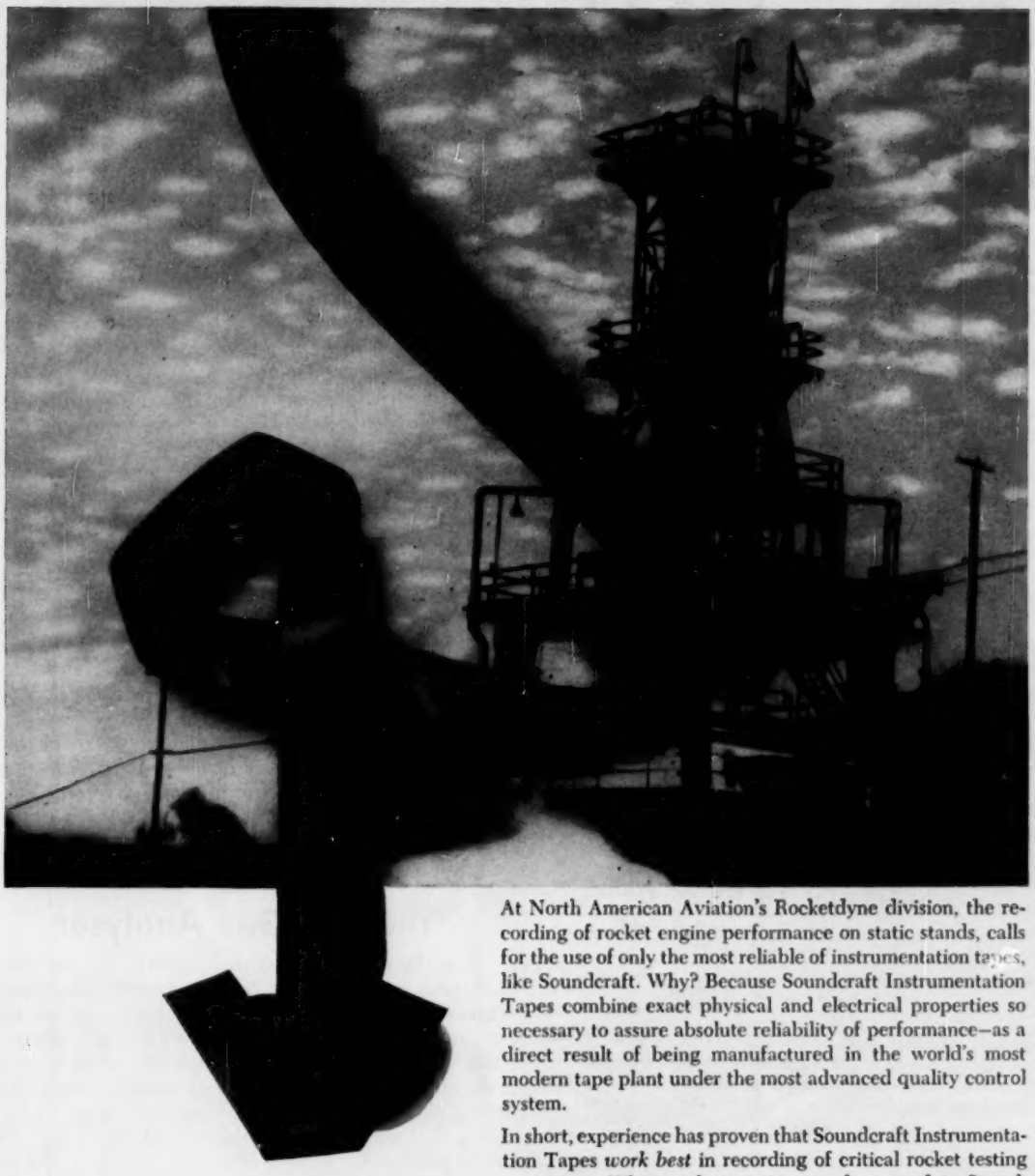
Nothing is lost in the translation with Benson-Lehner's new Machine Language Translator. What is gained, however, with this new solid-state instrument is the ability to translate machine languages. The Translator will automatically convert data in one digital code or form to, 1) output in another digital code or form, or 2) to a signal suitable for input into any Benson-Lehner Electroplotter or similar device. Translation speeds are dictated by the input and/or output modes, i.e., operating speed in conversion of digital magnetic tape to graphs is limited by the speed of the graphing instrument. If yours is a problem in converting digital data to graphs or getting any format of recorded digital data to talk to any other format, let us know. We will make up one of these for you...fast. Write to:

benson-lehner *corporation, 1860 Franklin Street, Santa Monica, California.*

CIRCLE 54 ON READER-SERVICE CARD

WORKING PARTNERS

ROCKETDYNE AND SOUNDCRAFT INSTRUMENTATION TAPES



At North American Aviation's Rocketdyne division, the recording of rocket engine performance on static stands, calls for the use of only the most reliable of instrumentation tapes, like Soundcraft. Why? Because Soundcraft Instrumentation Tapes combine exact physical and electrical properties so necessary to assure absolute reliability of performance—as a direct result of being manufactured in the world's most modern tape plant under the most advanced quality control system.

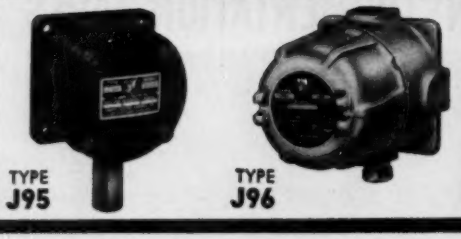
In short, experience has proven that Soundcraft Instrumentation Tapes *work best* in recording of critical rocket testing operations. Why not let precision-made, error-free Soundcraft Instrumentation Tapes go to work for you? Complete literature on request.

REEVES SOUNDCRAFT CORP. Great Pasture Rd., Danbury, Conn. • Chicago: 28 E. Jackson Blvd. Los Angeles: 342 N. LaBrea • Toronto: 700 Weston Rd.

CIRCLE 55 ON READER-SERVICE CARD

HAZARDOUS CONDITIONS? J95 J96

Use UE Explosion Proof PRESSURE-VACUUM CONTROLS



The Types J95 and J96 Pressure-Vacuum Controls are designed for applications in hazardous locations where explosive vapors or gases are present and close on-off differential control is required. In both units, pressure settings are uncalibrated and adjustment is made by an internal nut.

Adjustable Range . . .	J95 — Various ranges between 0 and 500 psi limits. J96 — Various ranges between 0 and 180 psi limits.
Switch Differential . . .	J95 — Factory pre-set for any differential between 2 and 30 psi. J96 — Factory pre-set for any differential between 3" W.C. and 2 psi.
Switch Ratings	Up to 15 amps. at 115 or 230 volts A.C. 20 amp. A.C. or D.C. switches also available.
Switch Types	N.O., N.C., or Double Throw — no neutral position.
Maximum Pressure . .	J95 — Up to 600 psi. J96 — Up to 180 psi.
Electrical Connections .	J95 — Lead wires attached to screw type terminals on switch via ½" NPT opening. J96 — Lead wires attached to terminal block via ¾" NPT opening.
Pressure Connection . .	Via a ¼" female NPT connection.
Enclosure	J95 — Cast iron with a gray, baked-enamel finish. For use in Class I, Groups C and D locations. J96 — Cast iron base and aluminum cover. For use in Class I, Group D; Class II, Groups E, F, and G; or Class III locations.
Mounting	Surface-mounted by four corner holes with clearance for ¼" screws.

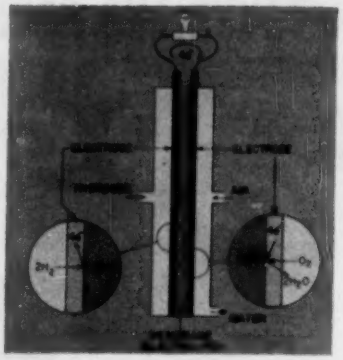
UNITED ELECTRIC *manufactures a complete line of temperature, pressure, and vacuum controls. For information on modifying standard units or providing custom-built units, consult a UE application engineer. For additional data on the Types J95 and J96, request new literature available.*

UE United Electric Controls COMPANY
91 SCHOOL STREET WATERTOWN MASS.

CIRCLE 56 ON READER-SERVICE CARD

ICS **BRIEFS**

Fuel Cell



A fuel cell is a continuous-feed electrochemical device in which the chemical energy of the reaction of a conventional fuel and air (oxygen) is converted into useful electricity. A fuel cell differs from a battery in two major respects: (1) it uses hydrocarbons (or some derivative, such as hydrogen) for fuel; and (2) it can operate continuously as long as fuel and air are available . . .

In General Electric's ion-membrane cell hydrogen and air enter chambers on opposite sides of the ion-permeable membrane, and penetrate the porous electrodes to contact the surfaces of the membrane. On the hydrogen side, the electrons are given up, collected in the electrode and conducted to the load. The hydrogen ions travel through the solid electrolyte to the other surface of the membrane where they combine with the returning electrons in the presence of oxygen. Result: the formation of water and the release of useful electrical energy . . . (*From new* 12-*page Bulletin GED*-4111, *General Electric, Aircraft Accessory Turbine Dept., Lynn, Mass.*)

FOR THIS LITERATURE CIRCLE 247 ON READER-SERVICE CARD

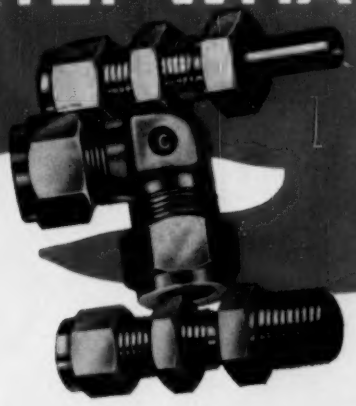
Thermal Gas Analysor

The Thermal Gas Analysor employs the principle of thermal conductivity. A platinum wire in a brass cylinder is heated by a constant current. Gas is pumped through at a constant rate and dried by $CaCl_2$ absorbers. As the wire loses heat to the surrounding gases its resistance changes, and this change is measured on a Wheatstone Bridge and registers on the meter. The readings are then calibrated against known gas concentrations . . . A multichannel stopcock adjusts the flow of gases to permit open circuit and closed circuit CO_2 and O_2 analyses. CO_2 concentration measurements can be made directly from the gas or from a bag. Response time is 10 to 15 seconds . . . . (*From new* 2-*page bulletin, Instrumentation Associates,* 17 *West* 60*th St., New Work* 23, *N. Y.*)

FOR THIS LITERATURE CIRCLE 248 ON READER-SERVICE CARD

Swagelok

HAS EXACTLY WHAT YOU NEED



Complete selection of shapes

for 1/16" through 1" O. D. Tubing

Available in all machineable metals & plastics

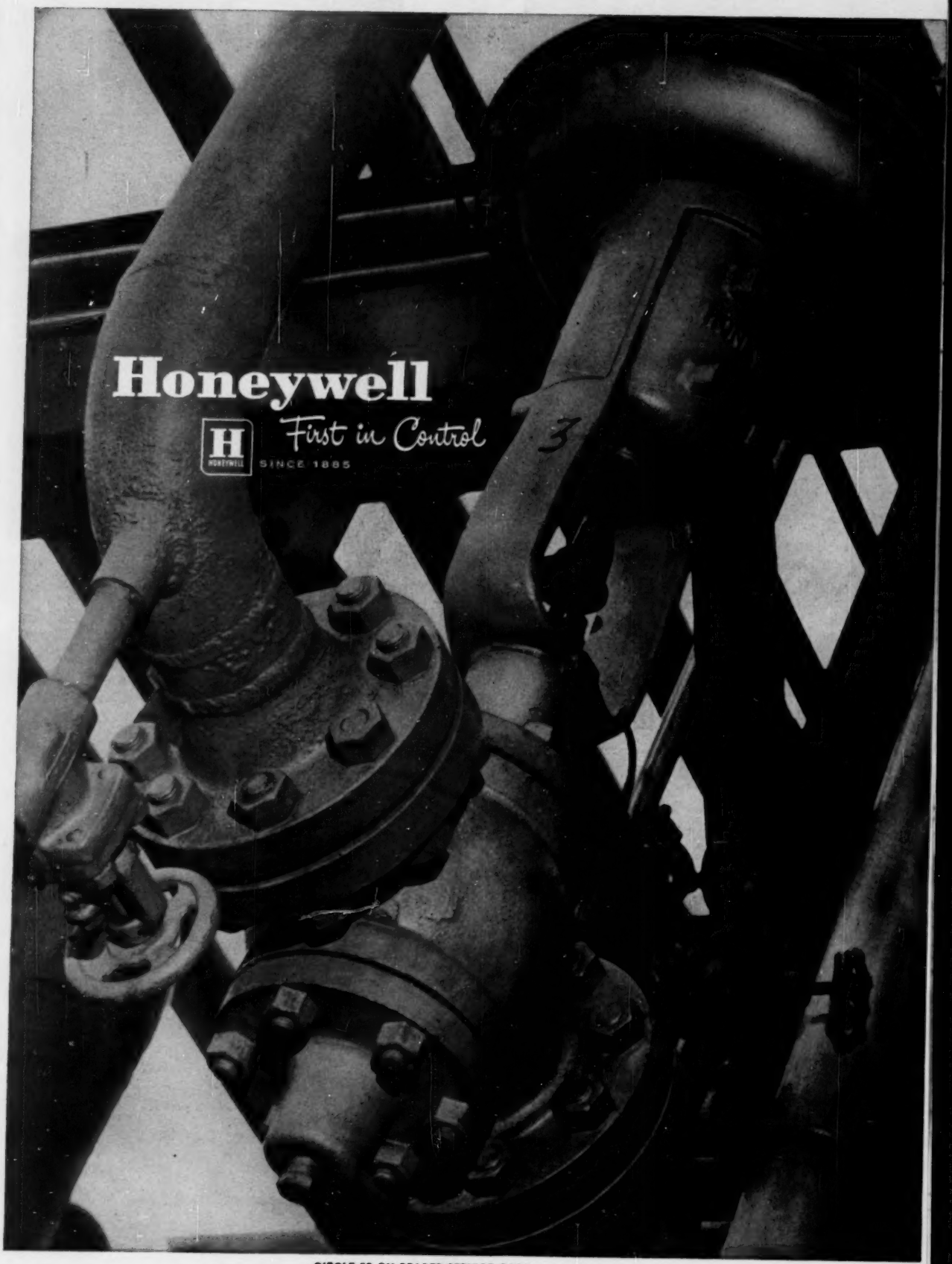
No special tools needed for installation

No special preparation of tubing

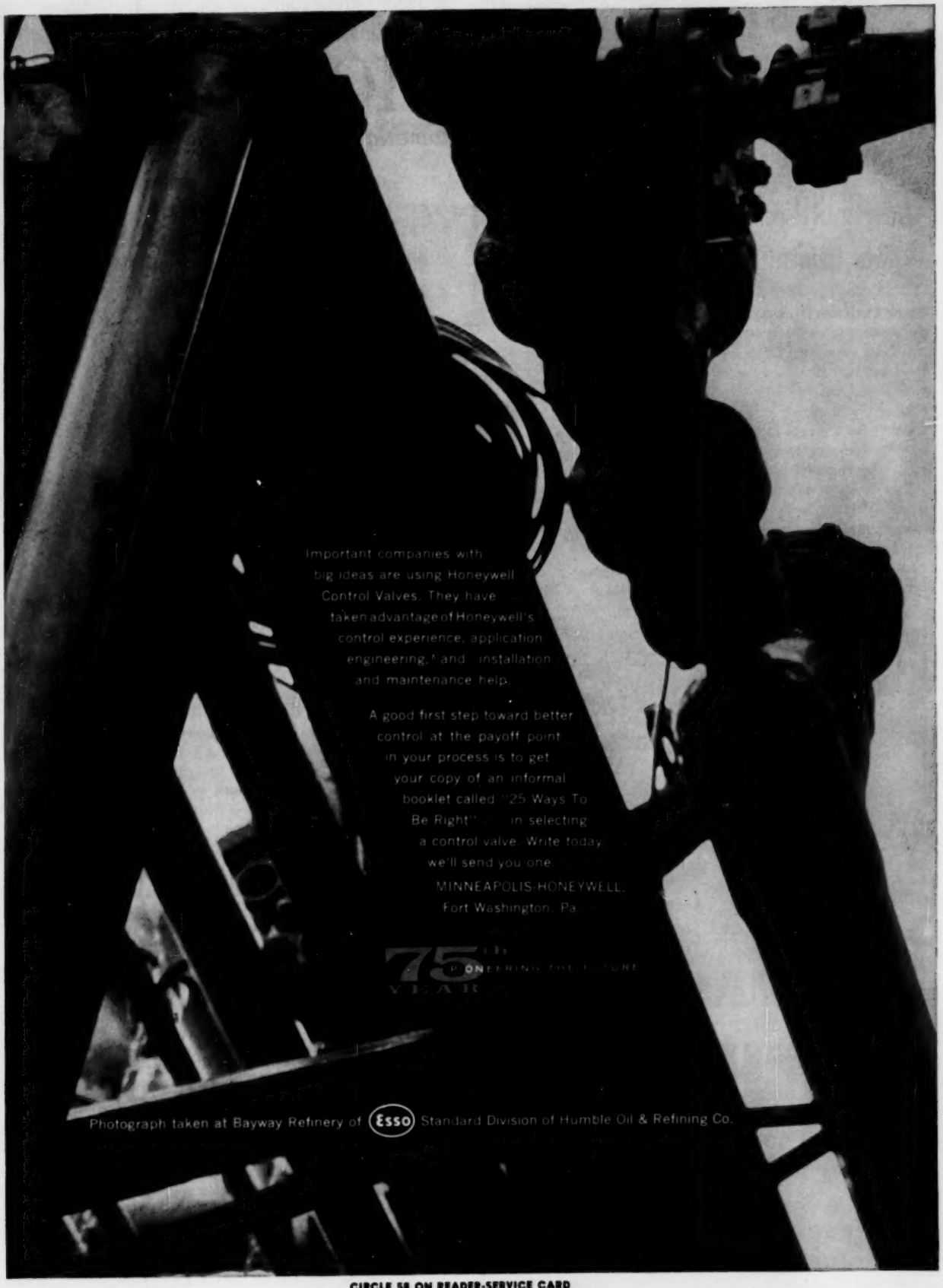
1¼ turns provides torque-free vacuum tight seal

CRAWFORD FITTING COMPANY • 884 EAST 140th STREET • CLEVELAND 10, OHIO

CRAWFORD FITTINGS (CANADA) LTD., NIAGARA FALLS, ONTARIO, CANADA



CIRCLE 58 ON READER-SERVICE CARD


Important companies with big ideas are using Honeywell Control Valves. They have taken advantage of Honeywell's control experience, application engineering, and installation and maintenance help.
A good first step toward better control at the payoff point in your process is to get your copy of an informal booklet called "25 Ways To Be Right" in selecting a control valve. Write today, we'll send you one.
MINNEAPOLIS-HONEYWELL
Fort Washington, Pa.
75
YEAR
Photograph taken at Bayway Refinery of Esso Standard Division of Humble Oil & Refining Co.

CIRCLE 58 ON READER-SERVICE CARD

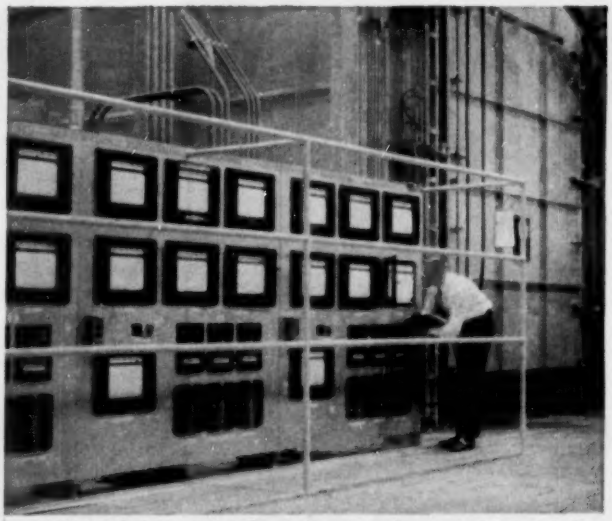
BRISTOL'S INSTRUMENTATION NEWS

News of instrumentation and automatic control in modern industry

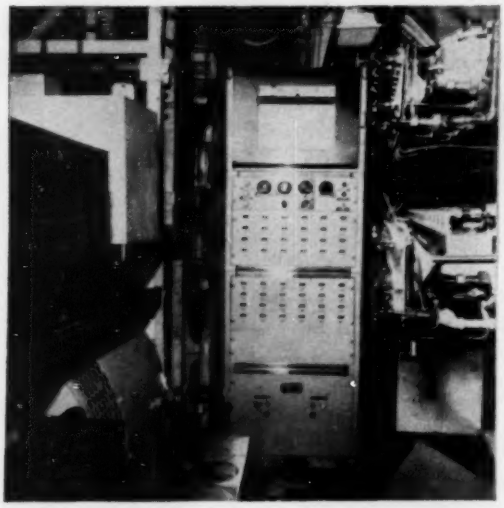
New multi-million dollar plant gets Bristol instrumentation

Bristol Electronic Dynamaster* Potentiometers play a vital part in the control set-up for the new fabricating plant of Anaconda Aluminum Company at Terre Haute, Indiana. They indicate, record, or automatically control temperatures in heat-treating, annealing, aging and soaking operations in a wide variety of furnaces throughout the plant. Other versatile Bristol Electronic Dynamaster instruments measure conveyor speed and function as multiple-zone safety-limit controls.

Comprising 11½ acres under one roof, the new plant turns out aluminum sheets, extrusions, tubes, ingots, and stamped shapes. Permanent records are a big plus in plant operation, says the furnace department foreman. "When a customer has a complaint or praise, we can always check the Bristol records. There's no guess-work involved anywhere."



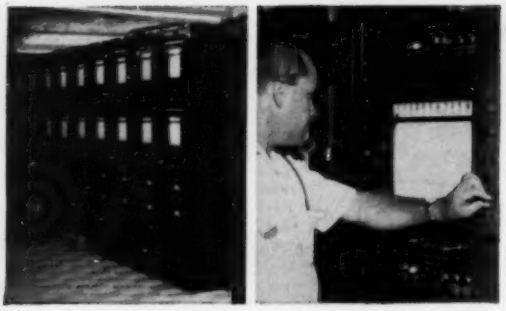
Bristol Electronic Dynamaster* Pyrometers shown here record and control an annealing furnace at Anaconda Aluminum Company's new, multi-million-dollar Terre Haute, Ind., plant. This is one of many panels featuring Bristol Dynamaster instruments in this ultra-modern new plant.



Bristol gets "deep dive diploma" on new Navy subs

The Navy's David Taylor Model Basin is using Gilmore Multichannel Strain Gage Plotters to assist in verifying the strength of new submarine hull designs. Gilmore Plotters, manufactured by Gilmore Industries, Cleveland, Ohio, are built around the basic Bristol Multi-point Dynamaster. Each new submarine design is tested by instrumenting the hull with strain gages and plotting strain vs load (depth). A plot is made at sea level and at 50-ft depth increments. A resultant straight-line plot for all stress points proves the design sound.

The USS ALBACORE was the first submarine tested with results plotted on these units. The ALBACORE embodies new design concepts which have contributed significantly to the spectacular performances of more recent atomic submarines. Most recent was USS SKIPJACK. This use of automatic strain-recording equipment saves manpower and time during the actual dive and in the subsequent analyses of the results.



Dynamaster* recorders monitor countdown variables in Titan missile blockhouse at Cape Canaveral

A large bank of Bristol Dynamaster recording instruments is prominent among the equipment supplied by The Martin Company's Cocoa Division for this blockhouse for the Titan ICBM at the Air Force Missile Test Center, Cape Canaveral. Dynamaster electronic instruments are also in other phases of the Titan ICBM program at Martin's Denver Division. Here they are used in the Propulsion Laboratory to check out kill parameters during tests, and also with the elevated temperature test equipment for aerodynamic flight simulation.

CIRCLE 59 ON READER-SERVICE CARD

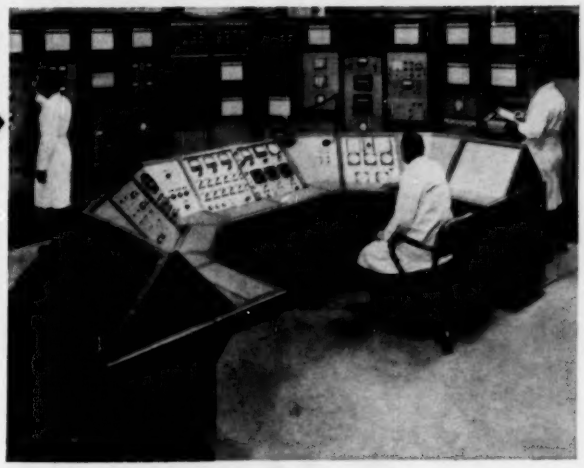
Electronic, nuclear ceramics development at Westinghouse aided by flexible temperature control panel

Bristol Round-Chart Program Controller, Double-Range Controller, Strip-Chart Recorder and Free-Vane Controller are tied into panel patchboard.

This instrument panel was designed by Westinghouse to give utmost versatility in furnace control at the Ceramic Materials Laboratory of Westinghouse Electric Corporation, Pittsburgh, Pa.

Furnaces controlled here are used in development of ceramic materials, such as nuclear fuels, thermistors, ferrites, ceramic resistors and other speciality ceramics. These range from low-temperature (only 1000°F) short cycles to high-temperature (up to 3000°F) cycles involving three soaks over a 72-hour period. Bristol instruments are playing an ever increasing role in modern basic and industrial research. Make sure you have full details before you purchase another instrument for lab use.

Dynamasters record vital data on new Army reactor



World's first mobile self-contained nuclear power plant and first U. S. gas-cooled reactor for generating power—these are the dual aims of the Gas-Cooled Reactor Experiment Program (GCRE-1), being carried out at the National Reactor Testing Station, Idaho, for the U. S. Army and U. S. Atomic Energy Commission by Aerojet-General Nucleonics.

Bristol Dynamaster Potentiometer and bridge instruments have been selected by Aerojet-General, prime contractors and builders of both the reactor and its control stations, to record vital reactor data. O.S

An Electronic Dynamaster* Potentiometer for every application!

Single-pen, two-pen, and multiple-record (up to 24 points) strip-chart instruments.
One- and two-pen round-chart recorders.
High-speed recorders (0.4 second).
X-Y recorders.
Extended range recorders.
Adjustable span and zero recorders.
Miniature 3-inch strip-chart recorders and indicators.
Electric and pneumatic controllers in both strip- and round-chart models—all types of control action and as time-program control.
Laboratory recorders—unmatched versatility for short-run testing.
Telemetering transmitters.
Drum-type precision indicators.
Multi-bank recorder—will accept up to 200 separate inputs and record them on 12-inch wide strip chart.
Selectomatic multiple point recorder that allows rapid changing of the number of points recorded.
Most models are available in case that fits standard 19" relay-rack without modification to instrument or rack.

TECHNICAL DATA

Extensive technical data on any Bristol instrument is yours for the asking. And, if you have special or unusual problems, our applications engineers will be glad to talk them over with you.

Write: The Bristol Company, 113 Bristol Road, Waterbury 20, Conn.

*T. M. Reg. U. S. Pat. Off.

BRISTOL

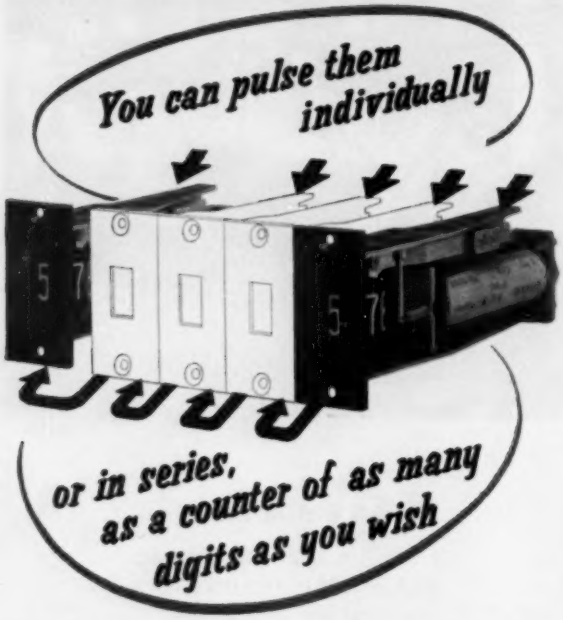
for improved production through measurement and control

AUTOMATIC CONTROLLING, RECORDING AND TELEMETERING INSTRUMENTS

Come in and see us at Booths 624-632 at the ISA Show

CIRCLE 59 ON READER-SERVICE CARD

It's the built-in contacts *that make these* SODECO *Digital Elements so versatile*



You can:

- Preset any figure remotely, by push button, by dial, or from punched cards
- Reset to zero electrically
- Or count down, get a signal at zero, recycle, or preset to a new figure in less than half a second per digit
- Specify them for addition or for subtraction
- Transmit numbers to remote locations

Ask for descriptive bulletin and wiring diagrams for these and other applications

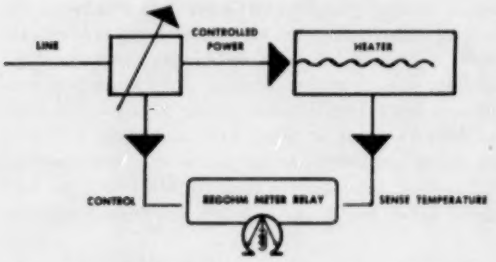
SODECO 1TD ten or twenty-five impulse/sec. counters are compact (⅞" x 1¾" x 4⅛"), rugged units suitable for flush mounting. The large, easy to read numbers are 5/32" wide and 13/32" high.

LANDIS & GYR inc.
45 West 45th Street
New York 36, N. Y.

CIRCLE 60 ON READER-SERVICE CARD

Control Directly from Microwatt Signals

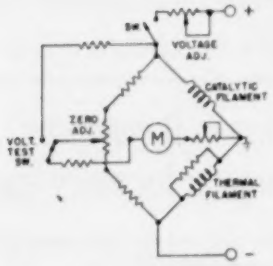
"Brain" of the new device is the Regohm, a plug-in component that produces output signals when set levels of input are reached. Control, alarm and indication are among the possible output functions . . . Flexibil-



ity is achieved through modular construction. Combinations of standard shock modules can solve a variety of process control applications. One example is the Magnetic Pre-amplifier module. It equips the relay to respond to input signals as low as a few microwatts. The need for expensive amplification of low-level transducer signals is eliminated . . . . (*From new* 4-*page Form* 5.504, *Electric Regulator Corp., Norwalk, Conn.*)

FOR THIS LITERATURE CIRCLE 249 ON READER-SERVICE CARD

Combustible-Gas Indicator



In the low range the sample flows through both cells, but the thermal conductivity effect of low concentrations can be neglected in comparison with the catalytic effect. The filament coil is connected as an arm of a balanced Wheatstone Bridge and operated at controlled temperature. Combustible gas present burns and raises the coil temperature—and its resistance—unbalancing the bridge. Meter shows the amount of unbalance as a degree of concentration of combustible gas . . .

In the high range the sample enters the thermal conductivity cell. The catalytic cell is sealed off so the gas can act only on the thermal conductivity cell. As the gas concentration increases, heat dissipation also increases. There is a cooling effect which changes the resistance of the coil in the thermal conductivity cell. This gives an upscale reading proportional to the concentration of the gas . . . (*From new* 2-*page Form H-557, Johnson-Williams, Inc., Palo Alto, Calif.*)

FOR THIS LITERATURE CIRCLE 250 ON READER-SERVICE CARD

Ⓐ **Bends hard or soft tubing. Open side design. Forms neat, accurate bends, any angle up to 180°. Calibrated. Specify No. 364-FH "Blue Dot" bender. Sizes: ⅛ to ⅜" O.D. tubing. Individual benders for each size.**

Ⓑ **Spare cutting wheel now included at no extra cost with this tube cutter! Fits behind retractable reamer. Instantly available. Cutter has free-wheeling, ball-bearing action. No. 274-FA Hi-Duty tube cutter for ⅛ to 1⅛" O.D. tubing.**

Ⓒ **For sawing wire-braid pressure hose or metal tubing. Assures square, clean cuts. Minimum wear on hacksaw blade due to special gripper. Extra-tight slide-to-size clamping. For ⅜ to 1½" O.D. hose or tubing. No. 384-F bolts to bench or clamps in a vise.**

Ⓓ **Industrial hard chrome cones now furnished on Imperial flaring tools. No extra cost! Smoother flares, up to 55% easier! Types for 45°, 37° and double flares. No. 300-F for 45° flares. No. 437-F for 37° flares. Sizes: 3/16, ¼, 5/16, ⅜, ½ and ⅝" O.D. tubing.**

Imperial offers you industry's most complete line of tube working tools with more work-saving features!

If it's new . . . it's from Imperial! The complete tubing tool line with more "firsts" to its credit continues to take the "work" out of tube working with *more* new developments!

That means no matter what the tubing . . . copper, aluminum, steel or stainless steel . . . or the type of job, you're adding greater accuracy, speed, ease and better craftsmanship to cut costs right down the line. *Tool up with Imperial and be first with the latest!*

Avoid lost time and grief by replacing labor-wasting tools NOW with years-ahead IMPERIAL tubing tools. See your Imperial distributor now, or write for Catalog 3121.

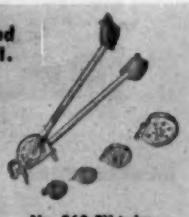
No. 300-F and No. 307-F Rol-Air flaring tools for 45° and 37° flares.

No. 140-F Test plug — for closing end of tube temporarily. Pressures to 100 lbs.

No. 206-F — Adjust-o-matic, slide-to-size tube cutter. For ⅜" to 2¼" O.D. Tubing.

No. 400-F flares stainless steel, titanium — other metal tubing to AN standards.

No. 270-F Gear type bender bends any type of tubing.



No. 360-FH tube bender combination—hard or soft tubing. 7 sizes: ⅛ to ⅝" O.D.

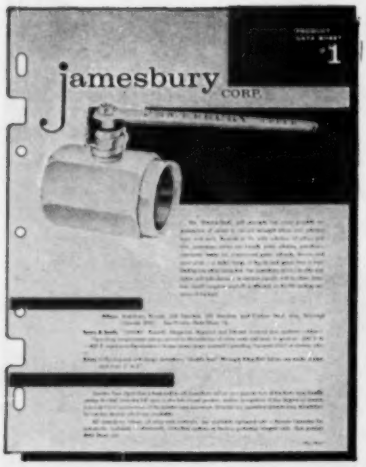
IMPERIAL

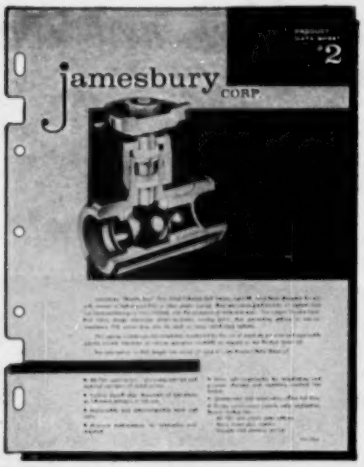
THE IMPERIAL BRASS MFG. CO.
6300 W. Howard St., Chicago 48, Ill.
Dept. ICS—80
In Canada: 18 Hook St., Toronto, Ontario

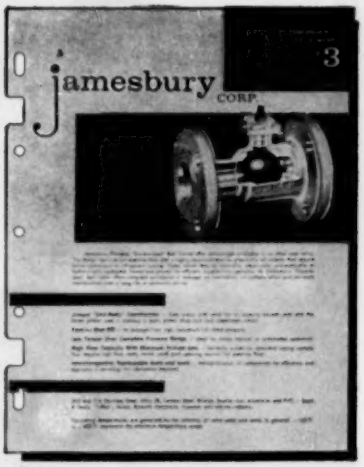
Emblem of Quality

CIRCLE 61 ON READER-SERVICE CARD

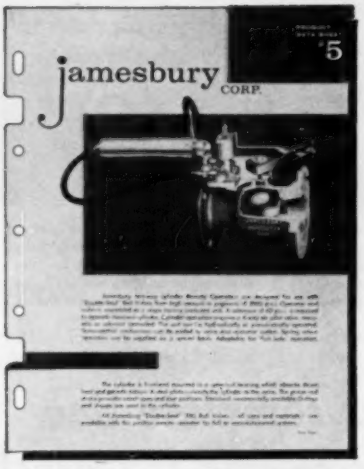
Yours For The Asking!

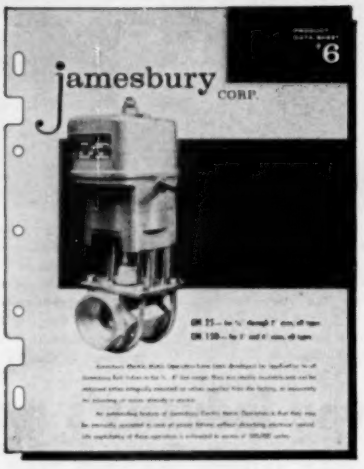


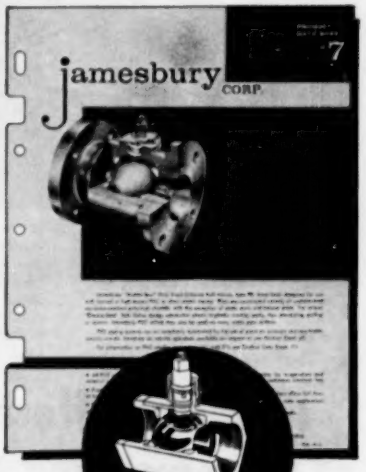


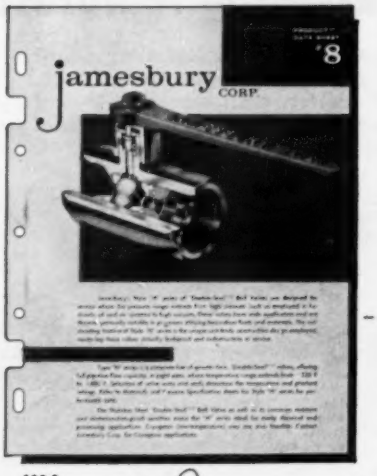


FACTUAL DATA









on Jamesbury BALL VALVES*

AS VERSATILE AS INDUSTRY ITSELF

Get the full story on Jamesbury Corp.'s complete line of "Double-Seal" Ball Valves and accessories. Learn why the Jamesbury "Double-Seal" Ball Valve has been labeled "as versatile as industry itself". Get all the facts on materials, sizes, etc. They are yours for the asking: the facts about Jamesbury Corp. – the nation's foremost exclusive manufacturer of Ball Valves.

*Patented

JAMESBURY CORP.
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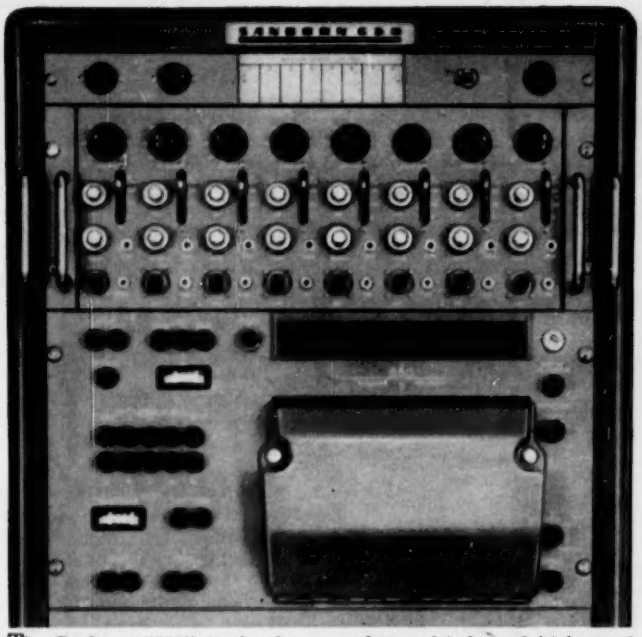
136-0

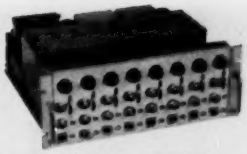
JAMESBURY BALL VALVES
HELPING BUILD OUR NUCLEAR NAVY

JAMESBURY CORP., 78 NEW STREET, WORCESTER, MASS.

Distributors in Principal Cities

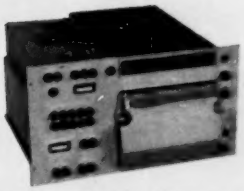
CIRCLE 62 ON READER-SERVICE CARD





8-channel Amplifier

+



2000 cps Optical Recorder

= a new 0 to 5000 cps direct writing system

SANBORN "650" SERIES

The Sanborn "650" is the first *complete* multi-channel high-speed optical recording system with medium gain general purpose amplification for each channel. Either the 8-channel amplifier or the recorder may be used separately. Together they provide a max. sensitivity of *2.5 mv/in* and a frequency response of *DC to 5000 cps* (within 3 db at 4 in peak-to-peak) in a multi-channel "direct writing" system.

MODEL 658-3400 GENERAL PURPOSE AMPLIFIER. Here is the first sensitive multi-channel amplifier designed specifically for use with high frequency optical galvanometers — those in the Sanborn "650" and any similar recorder. The single chassis has 8 separate channels, each one complete from floating and guarded signal input to galvanometer output. They include front-end modulator and input transformer, medium gain carrier amplifier, demodulator, filter and driver amplifier. An internal pre-emphasis circuit increases galvanometer frequency range from 2000 cps to 5000 cps in the "650" recorder. The all transistorized circuitry is mounted on easily serviced printed plug-in cards. The Amplifier chassis has an output transfer chassis on the rear which simplifies coupling to optical recorders of other manufacturers. External damping resistors are easily added when required.
Specifications: Sensitivity: 7.2 ma/mv input, max. . . . Attenuation: X2, 5, 10, 20, 50, 100, 200, 500, 1000, 2000 . . . Common Mode Performance: tolerance — 500 volts max; rejection — 140 db for DC . . . Input Resistance: 100,000 ohms all ranges floating and guarded.

MODEL 650 1- TO 24-CHANNEL OPTICAL RECORDER. The Model 650 Recorder provides high frequency direct writing recording, flexible housing and wide application possibilities. It may be used separately with from 1 to 24 plug-in type galvanometers of various natural frequencies. When used *with the 658-3400 Amplifier*, the recorder is equipped with eight 2000 cps galvanometers — extended to 5000 cps by the amplifier pre-emphasis circuit — for wide range, high speed, wide deflection recording. The recorder has nine electrically controlled (local or remote) chart speeds, beam interrupters for trace identification, timing lines at 0.01 or 0.1 sec intervals; amplitude lines with manual washout from ¼, ½, ¾ or all of the record; full chart width deflection for each trace and trace overlap.
Specifications: Input Sensitivity: 17.5 ma/inch (with 2000 cps galvanometers) . . . Chart Speeds: 0.25, 0.5, 1.0, 2.5, 5.0, 10, 25, 50 and 100 inches/second . . . Dimensions: 19" wide by 17½" by 16½" deep . . . Weight: approx. 120 lbs. (Data subject to change without notice)

Complete data is available from Sanborn Sales-Engineering Representatives located in principal cities throughout the United States, Canada and foreign countries.

SANBORN COMPANY

INDUSTRIAL DIVISION
175 Wyman Street Waltham 54, Mass.

At the WESCON SHOW — Booths 608-609

CIRCLE 63 ON READER-SERVICE CARD

Won't you join "the Company We Keep", with "Electro-Mech" specified on your next Control System job.

Perhaps not all of "the Company We Keep" would agree on the location of "The Industrial Engineering Center of the U. S." but many say that the New York-New Jersey-Connecticut-Pennsylvania Complex is a primary contender for this position.

However you might cast your vote on this controversial issue, there is one issue upon which we must all agree:

There is no area of industrial engineering activity that so clearly demands maximum coordination between customer and supplier than the manufacture of Custom Control Systems:

Examples—

- Preliminary design meetings;
- Fast, simplified interchange of final design information;
- Efficiency handling of design-change information;
- Coordination of incoming instruments supplied by others;
- Physical inspections by your personnel at our plant.

Electro-Mech Corporation has proved to be ideally located geographically to meet these requirements for many of our most distinguished industrial firms.

Electro-Mech Corp., Norwood, N. J.

Electro-Mech

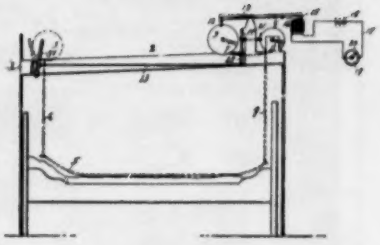
CIRCLE 214 ON READER-SERVICE CARD

IGS PANHANDLE PETE

Bed-Temperature Control

The object of the invention is to provide simple and efficient means in which the arrangement is such that a blanket or other bed-covering may be automatically deposited on the bed whenever the temperature of the room falls to a point where additional covering is required.

It will be observed that the supporting-frame is slightly inclined and that when the blanket is wound upon the roller 3 said roller is positioned near the upper end of the frame. To maintain the roller 3 in said position, it is normally held by a detent 12 on the end of a level 13, pivoted to a support 14 on the frame and carrying at its opposite end an armature 15 of an electromagnet 16. Said magnet is included in an electric circuit 17, of which



18 is the battery of source of electricity, and in which is indicated a thermostat 19 of any suitable construction, having a movable hand 20, adapted by its movement to alternately open and close said circuit.

Joseph Herbs
Patent 682,617
Sept. 17, 1901

Another reply to our ad for a systems engineer:

WESCO!
Personnel Div.
Long Bottom, W. Va.
Attn: *Panhandle Pete*:

Your employment ad in *INSTRUMENTS AND CONTROL SYSTEMS* in February interests me. I should like to apply for the position and will attempt to set forth my many varied qualifications in somewhat the same order as the items were enumerated in your ad. One reason for applying to WESCO! for employment is that I have noticed that no one down there does much and I would like to enjoy the same type of activity.

Your age requirement of young (not over 30) is interesting. I have been not over 30 for about 17 years. Your reason for this age is probably that you do not wish to pay the top salary of $9000 a year for the over-30 age. This I am willing to negotiate. I will settle for ½ of $9000 for the 17 years over 30 which I am. This amounts to $76,500 which is a real bargain since it has cost me more than that for these 17 years. A chance to purchase this service at a loss should interest you since your company records show you have a great deal of experience in losses.

You wish a well-rounded man. I am one of the most well-rounded around here. In fact I am getting even more so every year and if I just ignore a reasonable diet for several months I will be so well-rounded you won't be able to tell one end from the other.

You request both advanced degrees and 20 years of practical experience in several fields of modern systems engineering. I have made more than several advances and am familiar with both degrees F and degrees C. I have heard of degrees K but am not nearly as advanced in them as in F and C.

My practical experience in several fields encompasses more than 20 years but I consider this experience in fields just none of your business. (I believe questions such as this are contrary to the fair employment practices in all states.)

I have been responsible for a good deal of the systems engineering around here. My most famous is probably the engineered system for extending the morning coffee break right through the lunch hour. When Pennsylvania approves betting at harness tracks I will institute my new engineered modern system for "Taking the Track" (as long as my money holds out).

As I cannot state my extensive experience in all fields, systems, func-

tions, etc. I will merely take the one group of "fields" and answer for that category. Let me assure you that I have similar qualifications and experience for all other groups as well.

A. *Electronic*—There ain't nothing more electronic than a TV. I have experienced 74,286 hours of looking at, tuning, turning off, turning on, and getting way from this electronic device. I am so proficient that I can operate many of the controls even in dim light or almost total darkness. My experience goes to color since I saw it once and recognized it with no explanation from anyone. I am one of the few people acquainted with the outer orbit electrons and even know what makes them act that way.

B. *Electrical*—My electrical experience dates from the first time the lights went out. This was very illuminating. I am now an expert on fuses, candles, etc. I am also accepted as a qualified electric train operator under certain conditions (when the boys are not around).

C. *Pneumatic*—I am completely familiar with pneumatic systems and have been operating one of my own since birth. I have kept it in good condition and have not found it necessary to have any major repair or parts replacement. More experience than this you can't possibly get, except by getting older, which you don't want.

G. *Chemical*—My chemistry system has always been excellent. Everything I eat either turns to fat or . . . . . Your can't beat such a system.

I also learn very good. Six months ago I kuldn't even spell ingineer and now I am one. You say that my pay will depend on my ability. I should like to get a living wage. There is also the minimum wage law to consider.

Hydebound J. Thwigington
Pittsburgh, Penna.

Report for work on Monday.

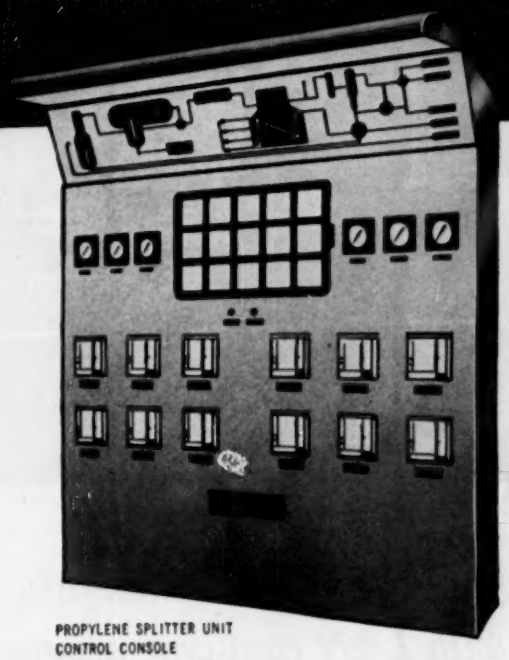
"I KNOW YOUR CONTROLS ARE THE BEST BUT I DON'T LIKE THE DESIGN OF YOUR SHIPPING CONTAINERS —"

Electro-Mech

ANOTHER ELECTRO-MECH FIRST:

VIS-A-SYSTEM®

INTEGRATED CONTROL CONSOLE



PROPYLENE SPLITTER UNIT
CONTROL CONSOLE

VISUALLY AND FUNCTIONALLY INTERLOCKED:

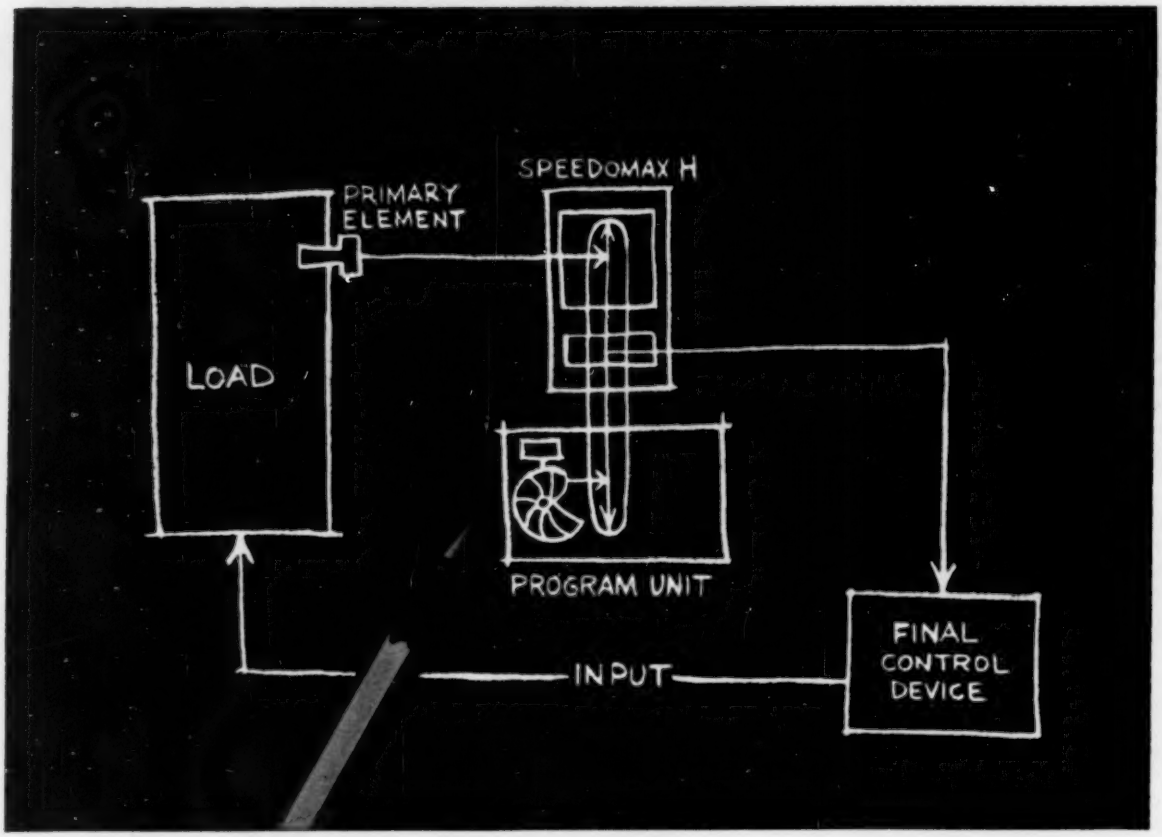
- GRAPHIC PROCESS DISPLAY
- ANNUNCIATION EQUIPMENT
- INSTRUMENTATION
- CONTROL ELEMENTS

With this control console, Electro-Mech Corporation introduces what is literally a new dimension to control-panel design. Here for the first time is realization of complete **integration** of all functional aspects of the control console.

You are invited to see a demonstration of an actual **VIS-A-SYSTEM®** Integrated Control Console at the Annual ISA Show: Booth 1705, New York Coliseum, September 26-30.

Electro-Mech Corp., Electro-Mech Norwood, N. J.

CIRCLE 214 ON READER-SERVICE CARD



Reproduce your time-temperature cycles exactly with L&N cam-type program control

At the flip of a switch you can heat . . . soak . . . and cool at a preset rate for a preset time with L&N's improved cam type program control! Whether your program is linear or non-linear, this control will continuously regulate input to reproduce *your* cycle . . . again and again.

Heart of the system is the program unit. Essentially it's a motor-operated cam and a control slidewire. The cam is calibrated . . . making it extremely easy to lay out and cut to any time-temperature cycle. Changing a cam to meet a new program takes only a minute. For additional flexibility, the unit has seven standard speeds . . . permitting a multiple number of programs.

Other elements in the control system include a primary element, a Speedomax® recorder and associated control relay, and a final control device. Any change detected by the primary element and measured by the recorder is checked by the program unit, which regulates the final control device to keep the process on cycle.

Also available is a motor-operated front setter type of program control. Recommended for linear programs only, this system offers great flexibility within the range selected.

Both types are available for Two-Position or proportioning control . . . will regulate input to electric or fuel-fired furnaces.

Can your process benefit from programmed heating and cooling? If so, it'll pay you to investigate L&N program control. For more information, call your nearest L&N office, or write 4955 Stenton Ave., Philadelphia 44, Pa. Ask for Data Sheet ND46-33(4).

LEEDS & NORTHRUP
Instruments · Automatic Controls · Furnaces

CIRCLE 64 ON READER-SERVICE CARD

IFAC CONGRESS, MOSCOW, 1960

R. OETKER, Karlsruhe, Germany

Head table at the opening session of the IFAC Congress in Moscow on June 27, 1960; l. to r.: M. Cuenod (Switzerland), H. Chestnut (USA), E. Gerecke (Switzerland), A. M. Letov (USSR).

THE KEENLY AWAITED first congress of IFAC (International Federation of Automatic Control) gathered automatic-control experts from 28 countries at Moscow from June 27 to July 2, 1960. 700 foreign and 400 Soviet control engineers participated in the congress held at Lomonossow University; 290 papers were given in the 10 simultaneously held lecture groups. The organizing committee was under the direction of Member of the Academy W. A. Trapeznikow.

1. New Trends in Automatic Control

Although the Congress had not been given a theme, a major topic sprang up spontaneously: *Self-adapting systems*, the subject of fifty papers alone. A further main topic was *sampling systems*, which were presented in 30 papers. This conforms with the trend in automatic control—the conventional, simple loop seems no longer to offer any new problems and to have attained a high degree of perfection.

The Congress has shown clearly that the elementary systems are able to fulfill higher tasks if superior control systems enable them to adapt themselves to these tasks. This can be termed "learning."

Concerning the papers, reference should be made to the Proceedings of the Moscow Congress (Butterworth Scientific Publications, 4-5 Bell Yard, Temple Bar, London WC 2), which will appear toward the end of the year.

Sampling controllers have been used for decades, but their advantages only lately have been recognized and explained—simplicity of amplifiers, independence from noise, and advantageous attitude at dead time.

2. Institute of Automatics and Telemechanics

Of the excursions in Moscow, the Institute of Automatics and Telemechanics of the Soviet Academy of Sciences was of greatest interest. In this institute, founded 20 years ago, 400 scientists work on research problems of automatic control. Under the direction of Prof. Trapezikow it comprises departments for servo systems (Zypkin), optimizing control (Lerner), pneumatic control (Aizermann), mathematical problems (Letov), components (Sutzkow), and controls systems (Chelustin).

The outstanding developed techniques of *plant simulation* is a characteristic of the institute. The visitor finds elaborate analog devices built from electronic modules, by which the behavior of the controlled plant is represented, mostly in actual time scale. Simulation also permits representation of extraordinary operational conditions and the development of automation conforming to requirements. However, the institute does not have the task of manufacturing devices.

The institute demonstrated the following: Optimizing control for a chemical process with 12 variables; control of a cold-rolling mill; telemetering and remote control of a pipeline installation; a self-adapting system of a position regulator for aircraft at rapidly changing atmospheric conditions.

The Russian scientists apparently work at their tasks with great dedication, and to go ways which sometimes appear unusual to us. Thus a pneumatic digital computer in the institute attracted atten-

tion which, although working more slowly than the electronic computers, presented a very interesting solution. Documentation is also handled carefully and it can be stated that the Russian scientists know the literature of the field well. The institute seems well organized and to have good direction.

One may look forward to the next IFAC Congress, 1963, in Switzerland. It can be expected that IFAC will develop into a federation which will serve international progress in the field of automatic control—and beyond that also, lead to better mutual understanding between nations.

The executive Council of IFAC, which determines the directives for the work of the federation for the next year, is: President—*A. M. Letov* (USSR): Past President—*H. Chestnut* (USA): First Vice President—*E. Gerecke* (Switzerland); Second Vice President—*O. Benedikt* (Hungary); Treasurer—*M. Cuenod* (Switzerland); Ordinary Members—*J. F. Coales* (UK), *G. Evangelisti* (Italy), *P. J. Nowacki* (Poland), *K. Kaneshige* (Japan), *J. G. Balchen* (Norway), *Zd. Trnka* (Czechoslovakia); Honorary Secretary—*G. Ruppel* (Federal Germany); Honorary Editor—*V. Broida* (France).

What Variables Can't You Measure Satisfactorily?

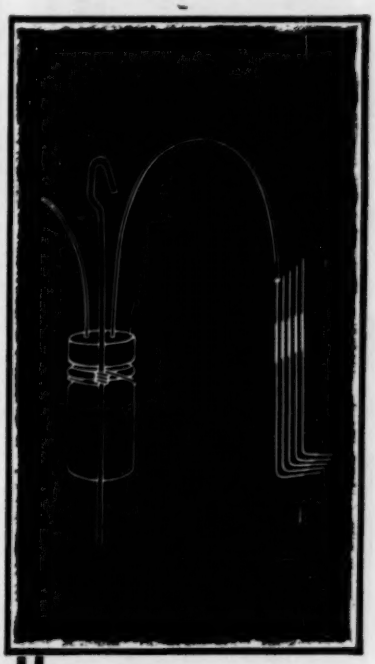
This is the question we asked our readers in a recent issue of *INSTRUMENTS & CONTROL SYSTEMS*. Here are some of the replies:

FLOW

VARIABLE	APPLICATION	PRESENT INSTRUMENT	DEFECT OF INSTRUMENT
Flow of #6 Fuel-Oil (Bunker C)	Fuel for open-hearth furnaces, 0-800 or 0-1500 gph.	(See I&CS, July, 1960, pages 1157-59)	
Fluid Flow and Pressure	Jet fuels; hydraulic oils, —65° to 700°F	Turbine flow meters; various transducers	low accuracy due to temperature; slow response
Air and Gas Flow	Probes in small passages	Probes of our design, scaling down from NASA standard	Questionable accuracy
Air Flow, Temperature	Cooling air low flow supplied to heat exchanger; 50° —250°F		
Oil Flow	Missile system testing 0-10 gpm— 10°F to 400°F	Orifice, turbine, variable area flowmeter	Low accuracy; cannot calibrate reliably at temp. extremes.
Gas flow	Cigarette smoke, 0-100 cc/second	Hot-wire anemometer	Slow response, non-linear
Differential Pressure to 1 part in 2000	Quality control testing; 120 psi, 250 psig max; jet engines	None	
Pressure Differential	0-88" Hg at high speed and high accelerations	Hg manometer	Poor reliability; low accuracy; slow response.
Gas Flow at High Pressure, Temperature	0-50 CFM	Hot-wire anemometer	Slow response; non-linear congested scale.
Air Flow to ±1%	Test, gas mass flow measurement, 1-20 lb/sec	Orifice, DP cell, relay.	Poor reliability; high maintenance; low accuracy; instability
Liquid Flow (0-300 cc/hr liquid	Pilot plant at 3000 psi	None	
Small Gas Flow	Cat reformer	Displacement system	Slow response; not continuous
Flow of Gas-Oil Mixtures		Separator, orifice meters, tanks	Poor reliability; high maintenance; low accuracy
Flow of Slurry	5-100 gpm	Magnetic	High first cost
Molten Aluminum Flow	30 to 120 lbs/hr through pipe	None	

VARIABLE	APPLICATION	PRESENT INSTRUMENT	DEFECT OF PRESENT INSTRUMENT
Mass Flow	Hot viscous rosin, 1 to 3000 lbs/hr	None	
Non-conducting Flow at Low Temperature	Lox	Turbine	Poor reliability; high first cost
Continuous Flow Measurement of Ethylene Glycol	Low temp. of 10°F	Magnetic flux	High first cost.
Fuel Flow	Acceleration tests of gas turbine; 0-400 #/hr.	Turbine flowmeter	Low accuracy; poor reliability; slow response
PRESSURE			
Pressure (0-4 psi)	Sanitary, food processing	Sealed diaphragm	No electrical transmission
Pressure 0-30 psia, psid	Calibration of transducers	Capsules; Bourdon tubes; manometer	Low accuracy; slow response.
High Altitude, Humidity	Altitude chambers to 1,000 000 feet; % RH at altitude	None	
Pressure	Liquid metals, 0-300 psi	Filled system	High maintenance
Pumping Rate of High Vacuum system	Metallic deposition	None	
Differential	Circulating pump, 35 psid; des. 3000 psi	Bellows	Poor reliability; high maintenance; slow response.
Blood Pressure in Arm or Leg	50 to 300 mm Hg, recording	Mechanical adaptation of auditory BP determination method	High cost; response slow and intermittant.
DISPLACEMENT, MOTION, STRESS			
Tension	Fourdrinier wire on paper machine	Strain gage	Difficult to apply
Torque/RPM	0 to 2500 RPM; 5 to 200 HP	None	
Water Speed Indicator	Hull speed thru water, 0-40 knots	Diff-pressure transducer	Low accuracy; slow response
Torque	Dynamometer, 0.1 to 3.0#	Numerous	High cost; low accuracy
Acceleration and Deformation	Road tests of cars		
Torque	Springs used on switchboard instruments; 10^{-3} to 10^{-2} gm-cm	Calibrated spring	Low accuracy
Horizontal Displacement (remote indication)	Diesel engine rack position; 1" total displacement in 0.001" steps	Linear potentiometer	High maintenance; vibration wears pot rapidly
Torque	Hydraulic motors, pumps, 4000-6000 rpm; 100 hp	Strain gage; break contacts	Poor reliability; high maintenance
Vibration	Pumps and compressors	None	
RPM	Rotors in closed housings; 40-80,000 RPM	Magnetic-pickup	Low response
Stress/strain of foil	1 to 7 mil film. (1-100 psi stress) to 200°C		Determination at varying sample dryness is impossible
Antenna Position	Potentiometer/resolver, ½°-360°	None	
Displacement (3 directional)	Flight Tests, ± 5" to ± .001"	Linear-motion pots	Single test expendability
Static strain	0-500 uinch/inch at high temperature	Strain gage	Low accuracy; high drif
Denier of Textile Fibers (grams/unit length 9000 m.)	Production of synthetic fibers; Denier—50 to 1000	Beta ray absorption; capacitance	High first cost; low accuracy; requires special fiber guiding and tensions

CANNON PENS



UP TO A YEAR WITHOUT REFILLING

Cannon Meter Pens are easily installed as original or replacement equipment in all standard recording instruments. Produce accurate charts of maximum legibility. No blurring or smearing.

- Ends unrecorded intervals. Unaffected by pulsating flows, chart speeds, or rapid pen movement.
- Sealed ink supply prevents clogging from atmospheric contamination.
- Two-way capillary action ink flow eliminates smearing, blurring.
- Available in five sizes and angles. Special pens designed to customer specifications on request.

Write today for information.

AMERICAN METER COMPANY

General Offices: Philadelphia 16, Pa.
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CIRCLE 65 ON READER-SERVICE CARD

E-A

DIRECT WRITING
RECORDERS

We prescribe for accurate, indisputable and permanent records, E-A Direct-Writing Graphic Instruments designed to record:

AC Amperes and Volts
KVA and KVAR
Power Factor
Frequency
AC or DC Watts
DC Amperes and Volts
DC Microamperes
DC Milliamperes
Speed
Events
Pressure and Vacuum
Position and Motion

Developed and refined over the past 50 years, all Esterline-Angus meters are simple in design and ruggedly built to give you years of reliable service under even the most severe operating conditions. In fact, **all E-A Recording Instruments are now guaranteed for two years!**

Send for Catalog 657A
Let your nearby E-A Representative help you. Write for his name and address.

The
ESTERLINE-ANGUS
Company

No. 1 in fine Recording Instruments for more than 50 years.

DEPT. G, BOX 596, INDIANAPOLIS 6, INDIANA

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TEMPERATURE

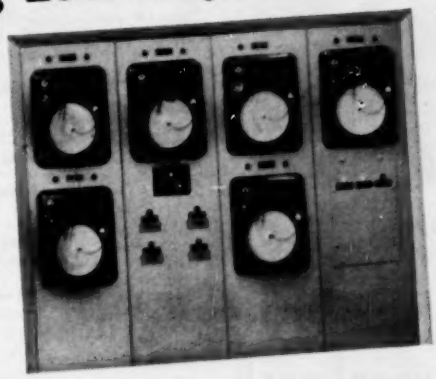
VARIABLE	APPLICATION	PRESENT INSTRUMENT	DEFECT OF INSTRUMENT
Temperature	Glass bending, 1100 to 1400°F	Rayotube	Slow response
Temperature	High-tem-x-ray camera, 0-1000°C to 0.1° or better	Voltage control by Sorensen regulator	Low accuracy; controls only to 1°C at 1000°C
Temperature (4500°F)	Electric-arc furnace.	None	
Missile Forces, Pressures, Temperature	2000°C and 1 usec response		
Heat transfer	High-speed aerodynamic testing of space vehicles	Thermocouples	Low accuracy (can't correct for heat flow; won't work at hi mach due to ionization effect
Differential Temperature	Ebulliometry-Cryoscopy; ±0.0001°C from 0 to 125°C	Thermistor; Wheatstone bridge	Complicated
Temperature	Muffle Control	Variable transformers	Low accuracy; high first cost; slow response; does not compensate automatically for voltage variations.
High Temp. (3600°F ±10°)	Molten steel	Plat-plat-rhod couple	High maintenance; limited to 3200°
Temperature to 2000°F	Rocket engine testing in reducing atoms.	Thermocouple	Slow response; replaced after each use.
Small Temperature Change	0° to 70°C	Thermocouple and millivolt galvanometer	Low accuracy; slow response; insufficient resolution
Temperature (2600-3300°F)	Steel processing	Immersion couple	Poor reliability; non-continuous reading
Temperature 10K to 20K°F	Plasma jets	None	
BTU	Pulverized coal feed, 0-20,000 BTU/#	None	
Burner Flame Alarm	Multiple-burner coal-fired boilers.	Temperature-, light-or color-sensitive rod.	Poor reliability; low accuracy

HUMIDITY, DENSITY, LEVEL

Moisture Stress in Plant Cells	0-30 atmospheres, in intact plants	None	
Relative Humidity	At all altitudes	W&D bulb; vortex; hygro elec element.	Low accuracy; poor reliability; slow response; limited range.
Moisture Content	Clay (brickets)	None reliable	
Time and Humidity	Evacuation of air from tank; time to evacuate tank related to % moisture.	Mercury column and electric timer.	Poor reliability; low accuracy; no way to determine effect of moisture on absolute time
Specific Gravity	Acid light hydrocarbon Mixtures, sp. gr. ±0.005	Radiation absorption	High cost; lack of temperature compensation; requires standardization in service
Consistency	Paper stock, 0-2% at 0.1 ACC	Pressure drop and torque	Low accuracy; slow response
Gas Density	Chemical processing, 0.0001 to 0.001 g/cc	None	
Density of Flowable Solid Materials	Automatic weighing systems, SG 0.4 to 1.0	Radiation density gage	High cost
Interface Level	Pulp bleach tower	Motor torque; product temperature.	Poor reliability; low accuracy.
Humidity	Missile compartment	Humidigraph W&D bulb	Slow response; adds moisture to object

American® Telemetering Equipment Means Operating Economy!

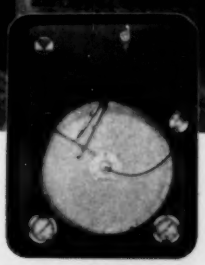
At this typical dispatching panel, one man does the work of many with American Telemetering and Telecounting equipment. At a central location, instantaneous, accurate flow and pressure readings are received from remote points and adjustments for load demands are made with remote-set controllers. Peak shaving can be performed with complete accuracy and confidence. Maximum gas sales to interruptible customers are assured.



AMERICAN METER CO. EST. 1836

AMERICAN®
METER COMPANY
INCORPORATED ESTABLISHED 1836

American Integrating Orifice Meters . . . Single, double and duplex-integrating models are available in a wide range of manometer types and working pressures.



American Series A-88 Controllers control flow, pressure, liquid level and other continuous process variables accurately, automatically and with a minimum of maintenance.

Whether your system is large or small, it will pay you to consult your nearest representative about the many economies American Telemetering Systems provide.

GENERAL SALES OFFICE: Philadelphia 16, Penna. • Albany • Alhambra • Atlanta Baltimore • Birmingham • Boston • Chicago • Dallas • Denver • Erie • Houston Kansas City • Los Angeles • Minneapolis • New York • Omaha • Pittsburgh • San Francisco • Seattle • Tulsa • Wynnewood

IN CANADA: Canadian Meter Company, Ltd., Milton, Ontario • Calgary • Edmonton Montreal • Regina • Vancouver

SUPPLIERS TO THE GAS INDUSTRY for Ironcase, Tinned Steelcase, Aluminumcase, and Welded Steelcase Meters • American-Westcott Orifice Meters Instruments • Reliance Regulators • Apparatus • Valves

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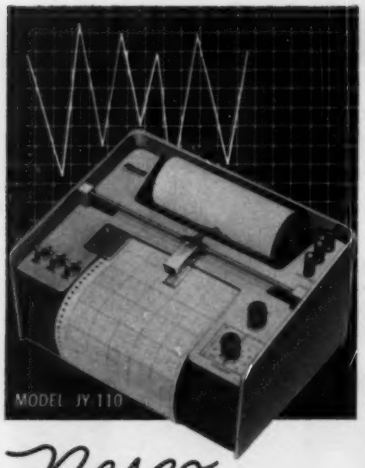


Nesco

GRAPHIC RECORDER

-offers exceptional sensitivity, speed, and accuracy...

as low as **$320.00**
(Model JY-100)

Here is a superior quality recording potentiometer, engineered for modern laboratories, and offering these advantages—all standard:

Fast balance time—only ½ second.
High accuracy—½% of span.
Span: 10 mv (Model JY-100); 10 mv to 100 V, with 10-step attenuator (Model JY-110)
5" chart width
Hum suppressor minimizes stray 60-cycle pickup.
Chopper stabilized—no zero-drift problems.
Floating high-impedance input — with separate chassis ground.
Many other quality features. Write for complete data.

Nesco
INSTRUMENTS, INC.
Manufacturers of Precision Recording Instruments
538 West 17th St., Costa Mesa, Calif.

CIRCLE 68 ON READER-SERVICE CARD

ANALYTICAL

VARIABLE	APPLICATION	PRESENT INSTRUMENT	DEFECT OF INSTRUMENT
H_2S in water	Foul water stripping of effluent, ppm	None	
Percentage of Petroleum Solvent in Mixture	Mixture of rubber cement, asbestos, dry filters, 2 to 20% by weight.	None	
Chemical and Physical Analyses	Color; specific gravity; % chemicals in tetraethyl load production	Various	Poor reliability; low accuracy; slow respons
Saturation Point of Carbon Bed	Solvent recovery	Gas analysis cells; Davis LER meter	Low sensitivity
Specific Gravity of Crude Oil	LACT, continuous measurement	None	
Specific Gravity; Heat Content	Natural gas	Ranarex; Thomas	High Cost
Continuous Viscosity	Centipoise 1-1000; Non-Newtonian Liquids	Rotating cylinder	Difficult to adapt to laboratory glassware.
Color, pH, Brix	Pineapple quality control; grading slided fruit for packing at rate of 10 slices/second		
pH	Sulfite wood pulping, pH 1.0 to 6.0	pH meter	Poor reliability; electrode life is only a few hours.
Total Hydrocarbons in Auto Exhaust Gas	Automative test, 0-1000 ppm	None	
Air/Fuel Ratio	Engine tune up, ranges 12/1-18/1.	Resistance bridge and thermal conductivity	Poor reliability; high maintenance; low accuracy
pH	Biochemical steam sterilization, pH 2-10	High temperature electrodes	High maintenance; fragile electrodes
Catalyst Activity, pH and Carbon	Cat reformer	None	
Normality of Acids Salts	Standardizing solutions	pH	High first cost; low accuracy; inability to switch between stand ard and sample, and other conditions con trolling pH
End point of light hydrocarbons	Oil Refining	None	Manual

ELECTRICAL

Current (10^4 Amps)	Resistance spotwelding	Magnetic galvanometer	Poor reliability; low accuracy; high maintenance
Neutron Flux	Flux plotting in nuclear reactors, 10^{12} to 10^{14} N/cm^2-sec		
Electron Beam Current	100 ua to 100 ma	Clamp-on ammeters or magamps	Below range of instrument.
AC Voltage, Current	Test missile guidance system, ±.01%	Hermach-Engelhart	Low accuracy; impractical for production line.
Magnetic H and B between Pulsed Toroid Coils	Toroid coil mfg.	None	
Linear Voltage Change	Sweep generator, 50 volts at ±0.01%	None	
Input and Output Impedances	Amplification stages and oscillators; Z of 10 ohms to 10 megohms	Voltage and current measured; E/I computation.	Poor reliability; low accuracy; slow response
Turns Ratio	Transformers	Impedance Ratio	

TESTS PROVE DOLLARS SAVED...

By new Instrument Record Marking System now installed at Mobil Oil Paulsboro Refinery

Controlled field tests by Mobil Oil Company engineers show *substantial* savings on meter recorder maintenance—with Esterbrook's new Meter Marking System on round chart recorders.

New! A *customized* Meter Marking System with easy "Slip-In" Cartridge

Custom-built by Esterbrook for the Paulsboro (N.J.) test site, Mobil's new Marking System replaces manually-filled, open-bucket type pen system with *modern ink-cartridge convenience.* Designed by Esterbrook's Technical Products Division, this system won't clog, won't flood or break down. *Result:* minimum maintenance.

Give your customers the benefit of ink cartridge convenience and a century of experience in the recording product you build...*Now*—Esterbrook's Technical Products and Instrument Division will custom-design and build a new marking system for any type recorder. Satisfaction guaranteed. For further information, write:

TECHNICAL PRODUCTS AND INSTRUMENT DIVISION

The Esterbrook® Pen Company

Camden 1, New Jersey

NAME _____

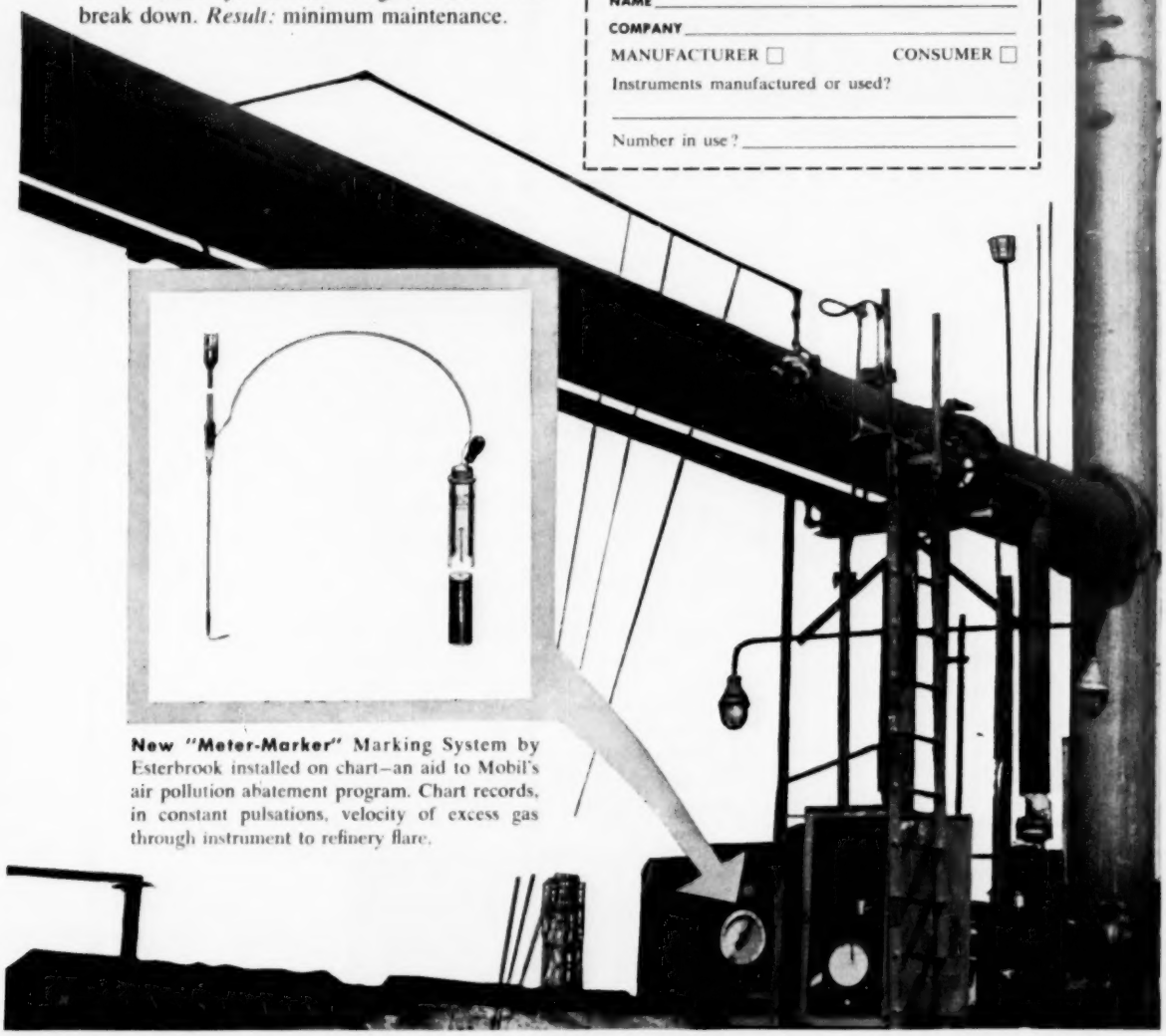
COMPANY _____

MANUFACTURER ☐ CONSUMER ☐

Instruments manufactured or used?

_____

Number in use? _____



New "Meter-Marker" Marking System by Esterbrook installed on chart—an aid to Mobil's air pollution abatement program. Chart records, in constant pulsations, velocity of excess gas through instrument to refinery flare.

Esterbrook Pen Company, Ltd., Birmingham 4, England • Esterbrook Pen Company of Canada, Ltd., Toronto, Ontario, Canada
Esterbrook Pen Company de Mexico, S.A. de C.V., Mexico, D.F., Mexico
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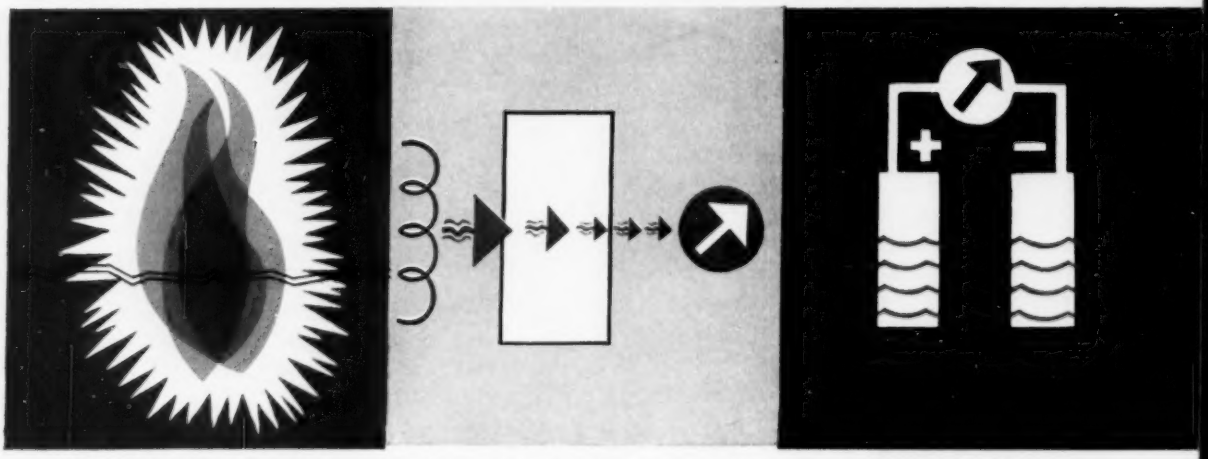
MSA Instruments apply all these principles



Catalytic Combustion

Depolarization

Infrared Analysis: Now MSA bridges another important instrument gap. The bridge is a simplified low-cost infrared analyzer. One that substantially reduces the size, complexity and high cost of most available instruments.

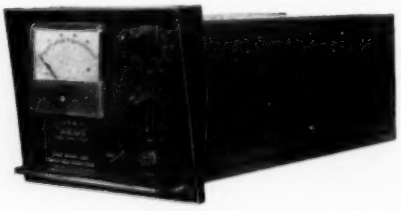
The new M-S-A® LIRA® Model 300 IR Analyzer has the inherent reliability and accuracy of earlier MSA analyzers. But it's for use in applications where extreme sensitivity isn't so essential. Lets you analyze gases, vapors and liquids faster, more economically.

Weight: only 40 pounds. Size: a trim 8″ x 10¼″ x 20″.

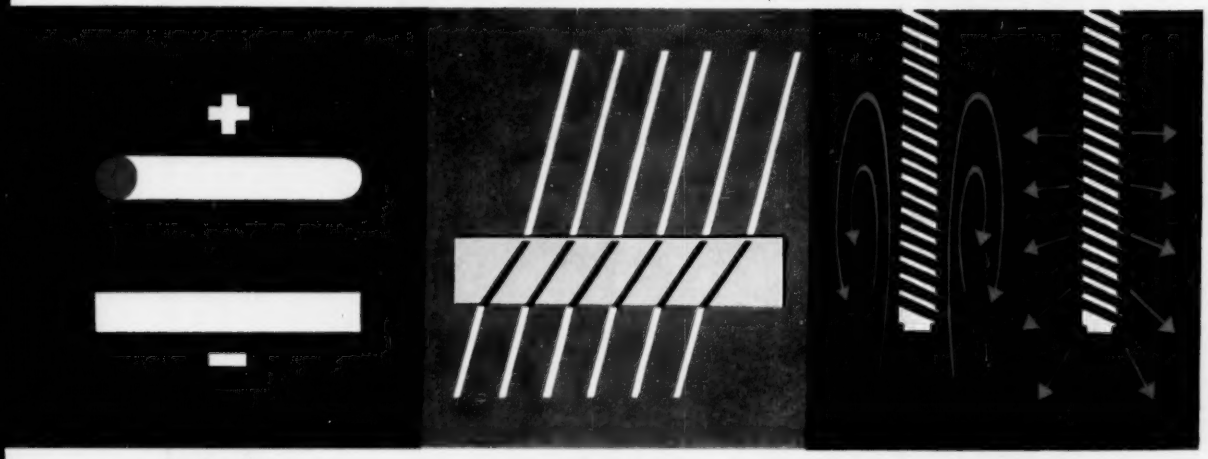
Our techniques and principles involve a number of other interesting instrument concepts. They're reflected in the symbols spanning the pages above.

An MSA Instrument Specialist can apply one or more of these principles to your immediate problems. So talk with him about our precision instruments. They're sturdy instruments. And they are reliable.

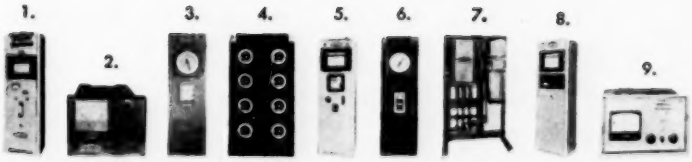
Write for new M-S-A LIRA Model 300 bulletin or any of our other process stream analyzer literature.



for dependable process stream analysis



Ionization **Refraction** **Thermal Properties**

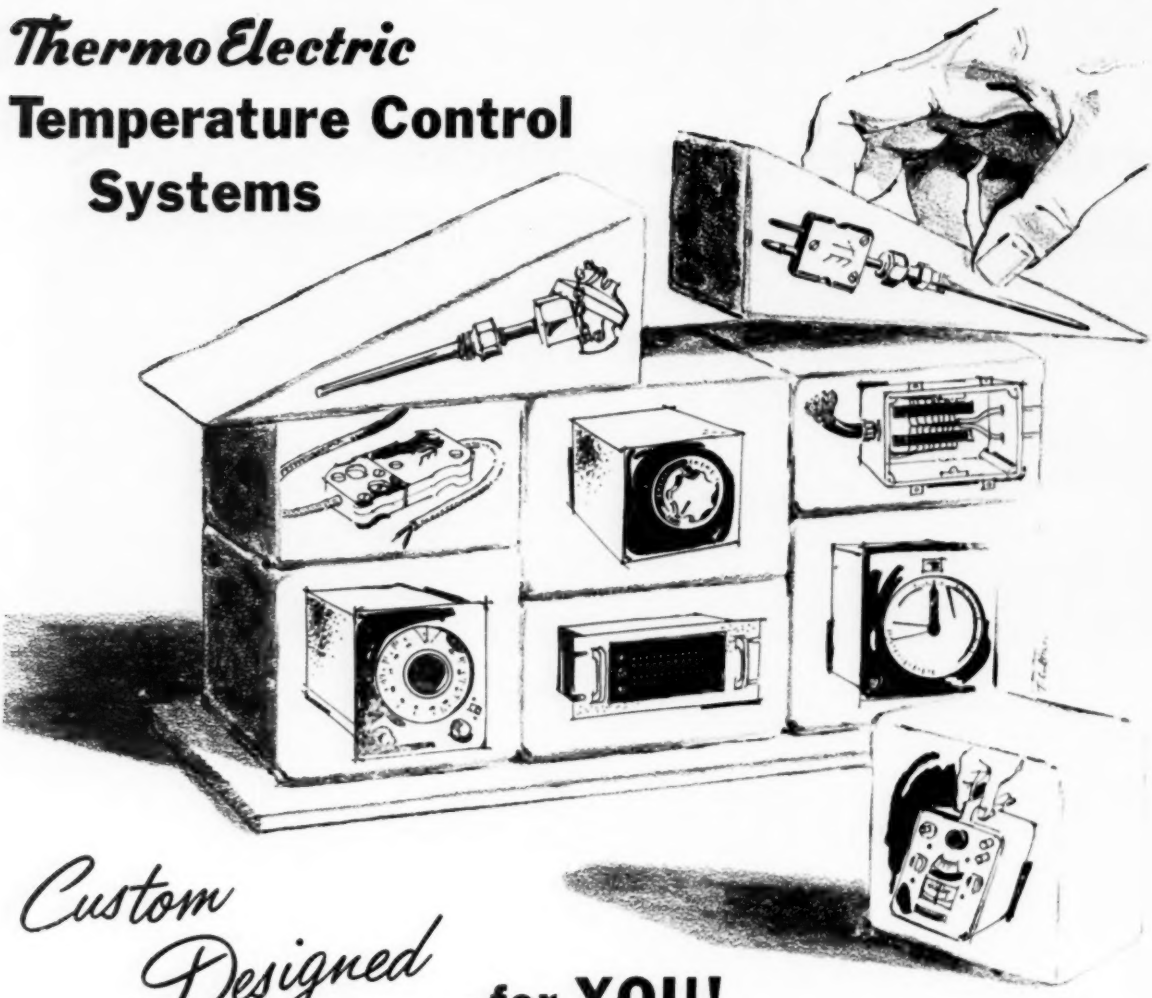


1. M-S-A® LIRA® Infrared Analyzer Model 200 **2.** M-S-A® LIRA® Infrared Analyzer Model 300 **3.** M-S-A® Inert Gas Analyzer **4.** M-S-A® Combustible Gas Analyzer **5.** M-S-A® Thermatron Analyzer **6.** M-S-A® Oxygen Indicator **7.** M-S-A® Water Vapor Recorder **8.** M-S-A® BillionAire* Analyzer **9.** M-S-A® Process Refractometer

*Trademark

INSTRUMENT DIVISION
Mine Safety Appliances Company
Pittsburgh 8, Pennsylvania

Thermo Electric Temperature Control Systems



Custom Designed — for YOU!

Thermo Electric advanced systems-building components permit custom designing to satisfy your temperature monitoring, indicating, recording, or controlling requirements, exactly and economically. Starting with T. E. thermocouples—standard or special calibrations—from 1 inch to 66 feet and longer, accessories are carefully selected by T. E. applications engineers to relay any number of signals to your instrument panel. Quick-coupling plug and jack connectors and panels, extension wire and cable are precisely matched to eliminate false emf's. Junction boxes, rotary, key or push-button selector switches are all designed and constructed by T. E. to the highest quality standards.

To monitor, indicate, record or control process variables, T. E. offers the compact Signaling Controller—the Indicating Controller and Indicating Recorder with large, easily-read scales, or special multi-point monitor systems. All instruments have front-set controls, complete in-the-field range interchangeability, ease of service, and feature the new High Gain Relay or Servo Amplifiers with high sensitivity and exceptional stability.

The portable "MiniMite" Indicator with 23" scale and 0.25% scale accuracy, can be used to indicate on-the-spot temperature or for calibration and test work.

Let us assist in building your process control system.

Send application details on your letterhead today to Dept. 12

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In Canada: THERMO ELECTRIC (Canada) LTD., Brampton, Ontario

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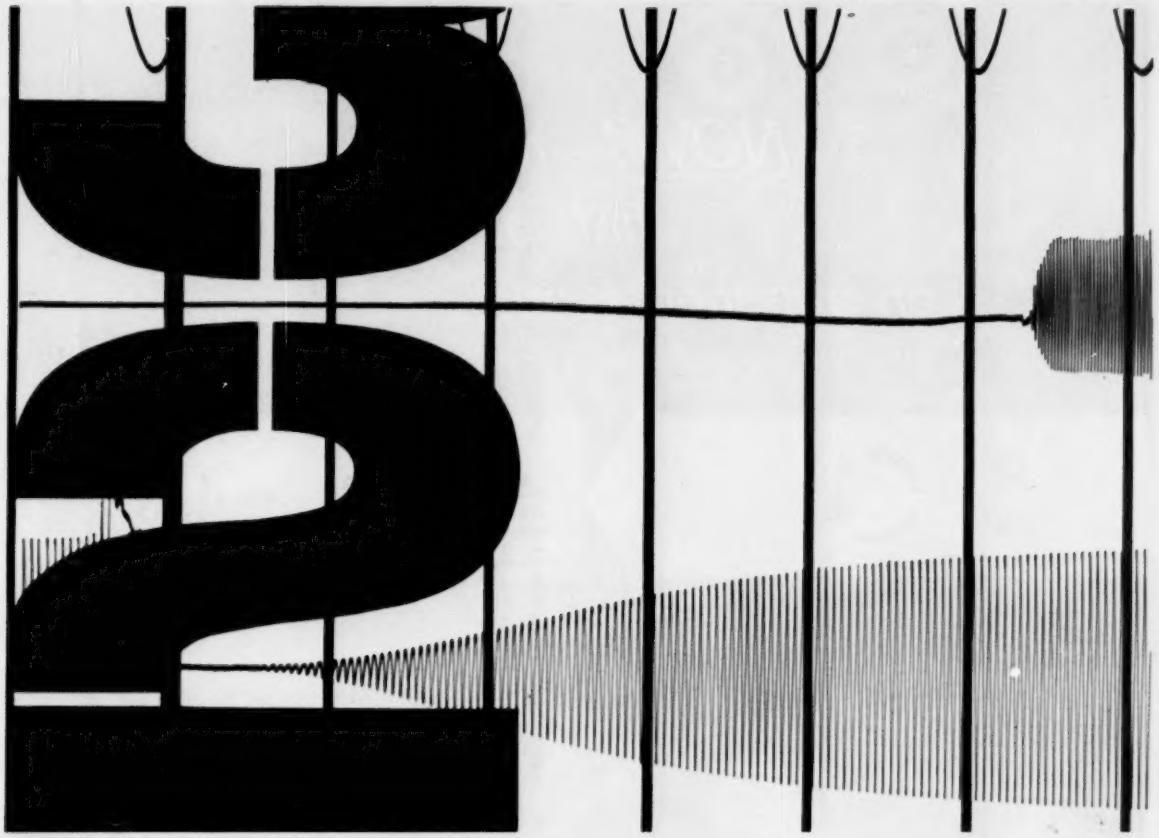

Complete line . . . prompt delivery. That sums up Du Pont Lino-Writ Photorecording Paper. Lino-Writ 4 is the fastest, toughest, whitest paper available. Writing speeds up to 50,000 inches per second. Ultra-thin, all-rag stock has unusual wet or dry strength.

We also offer Lino-Writ 1, 2 and 3 . . . one for every test requirement. And, they're all backed up by Du Pont's prompt, efficient delivery designed to save you time.

For more information on our photorecording papers, write: E. I. du Pont de Nemours & Co. (Inc.), Photo Products Department, Wilmington 98, Delaware. In Canada: Du Pont of Canada Limited, Toronto.

This advertisement was prepared exclusively by Phototypography.

LINO-WRIT

DU PONT
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Better Things for Better Living
. . . through Chemistry

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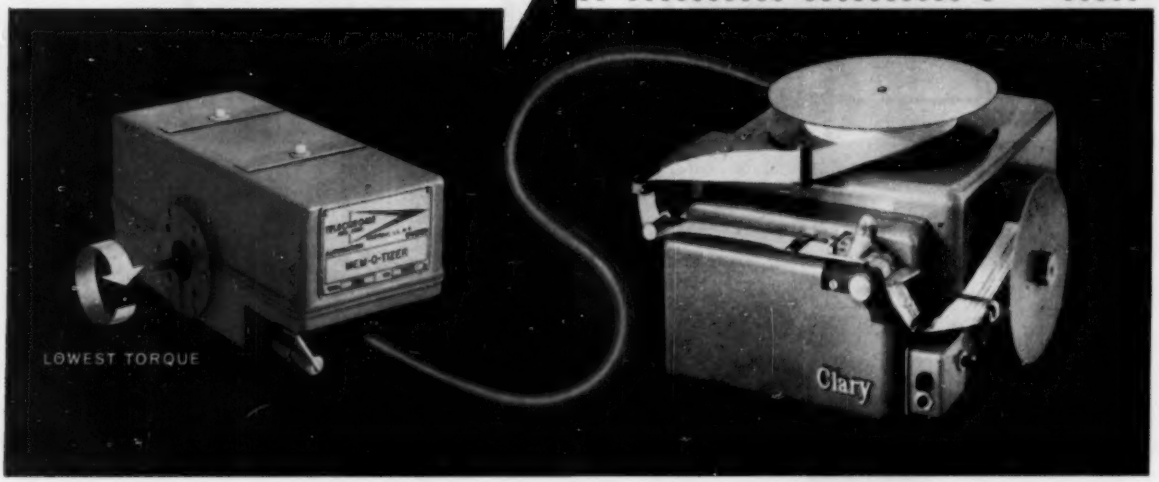
NOW!—record shaft position data on punched tape!



- Mem-O-Tizer© operates directly from data source without amplifiers or servo systems.
- Versatile punched tape provides permanent record you can file, mail, or directly teletype.

The Mem-O-Tizer converts angular position to any digital code you want...and it requires no electronic components to do it!

What's more, you can permanently record the information on the Clary Model 703 Tape Perforator (above). Punched tapes speed up operations, increase accuracy, allow rapid transmittal of vital information from one point to another.

A precise analog-to-digital converter, the Mem-O-Tizer is also a storage accumulator of time, events, pieces, or quantities. *A memory of the last reading is a standard feature!*

- Lowest torque (.005 inch-ounce).
- Non-ambiguous definition.
- Dynamic readout to 125 rpm.
- Output codes: Decimal, Binary, Modified Binary, Binary Decimal, Gray, 5 Bit, 6 Bit, 7 Bit, 8 Bit.
- Accurate and reliable over long periods.
- Flexible with standard components.
- Resolution one part in 2 million.
- Memory of each reading until next reading.
- Converts temperature, time, level, weight, flow, rotation, pressure, position...to digital values.

For further information and engineering assistance, write or phone

AUTOMATION DIVISION

TELECHROME manufacturing corp.

26 Edison Street, Amityville, Long Island, New York • Telephone LI 1-3600

MID-WESTERN ENGINEERING DIVISION, 106 W. ST. CHARLES ROAD, LOMBARD, ILLINOIS, MAYFAIR 7-6026 • WESTERN ENGINEERING DIVISION, 13635 VICTORY BOULEVARD, VAN NUYS, CALIFORNIA, STATE 2-7479 • SOUTHWESTERN ENGINEERING DIVISION, 4207 GASTON AVENUE, DALLAS, TEXAS, TAYLOR 3-3291

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How to get ACCURATE PRESSURE CONTROL IN SPITE OF DEMAND CHANGES

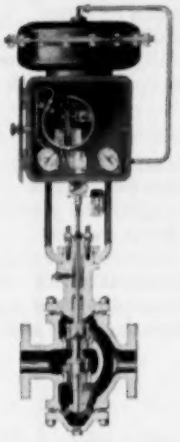
ask your FISHER MAN about the

WIZARD II PRESSURE CONTROLLER

with new and improved features

1. **VOLUME RELAY** for faster response to pressure changes.
2. **RESET FEATURE** for greater stability and pin-point control, adjustable from .005 to 1 minute per repeat.
3. **MEASURING ELEMENT** may be brass, steel or stainless steel Bourdon tubes for pressures from 30 to 15,000 psi or Bellows assemblies for pressures below 30 psi and vacuum.

WIZARD I



PRESSURE CONTROLLER

The original Wizard I Pressure Controller is still available for those applications not requiring volume relay or reset features. The simplicity of a self-operated regulator and the accuracy of a pilot or relay operated regulator are found in the Series 4100U. This is, unquestionably, the reason for the continued popularity of the Wizard I series.

As for all Wizards, the Series 4100U is furnished with a universal case which enables the unit to be flush or surface mounted or mounted on yoke of a control valve. Measuring Elements: Bourdon Tube—Bronze, Steel or St. Steel—Ranges 25 to 7,500 psi. Bronze or St. Steel Bellows for vacuum to 25 psi.

The Wizard II has been designed to specifically meet the demands of modern, complex systems requiring closer and faster control. The Wizard II retains the basic simplicity and dependability of the Wizard 4100U, plus more speed and accuracy.

The new design consists of two sub-assemblies encased in a weather proof die cast aluminum housing which is provided with a ¼" pipe threaded vent. Either sub-assembly can be removed without disturbing case mounting. The simple but effective proportional band adjustment (2 to 100%) and the reset adjustment (.005 to 1 min/repeat) along with ease of reversing the action of the Wizard II, have contributed much to its popularity in process control work. All Wizard II controllers, with exception of differential models, can be supplied with a process or controlled pressure gauge installed inside the case.

Careful and exhaustive tests and years of field use have conclusively proved that the Wizard II measures up to rigid Fisher standards.

A COMPLETELY DESCRIPTIVE AND ILLUSTRATED BULLETIN ON THE WIZARD II IS YOURS FOR THE ASKING. WRITE FOR BULLETIN No. D-4150B OR BULLETIN D4100 ON WIZARD I.

IF IT FLOWS THROUGH PIPE ANYWHERE IN THE WORLD...CHANCES ARE IT'S CONTROLLED BY...

FISHER GOVERNOR COMPANY

Marshalltown, Iowa / Woodstock, Ontario / Rochester, England

BUTTERFLY VALVE DIVISION: CONTINENTAL EQUIP. CO., CORAOPOLIS, PA.

FISHER®

SINCE 1880

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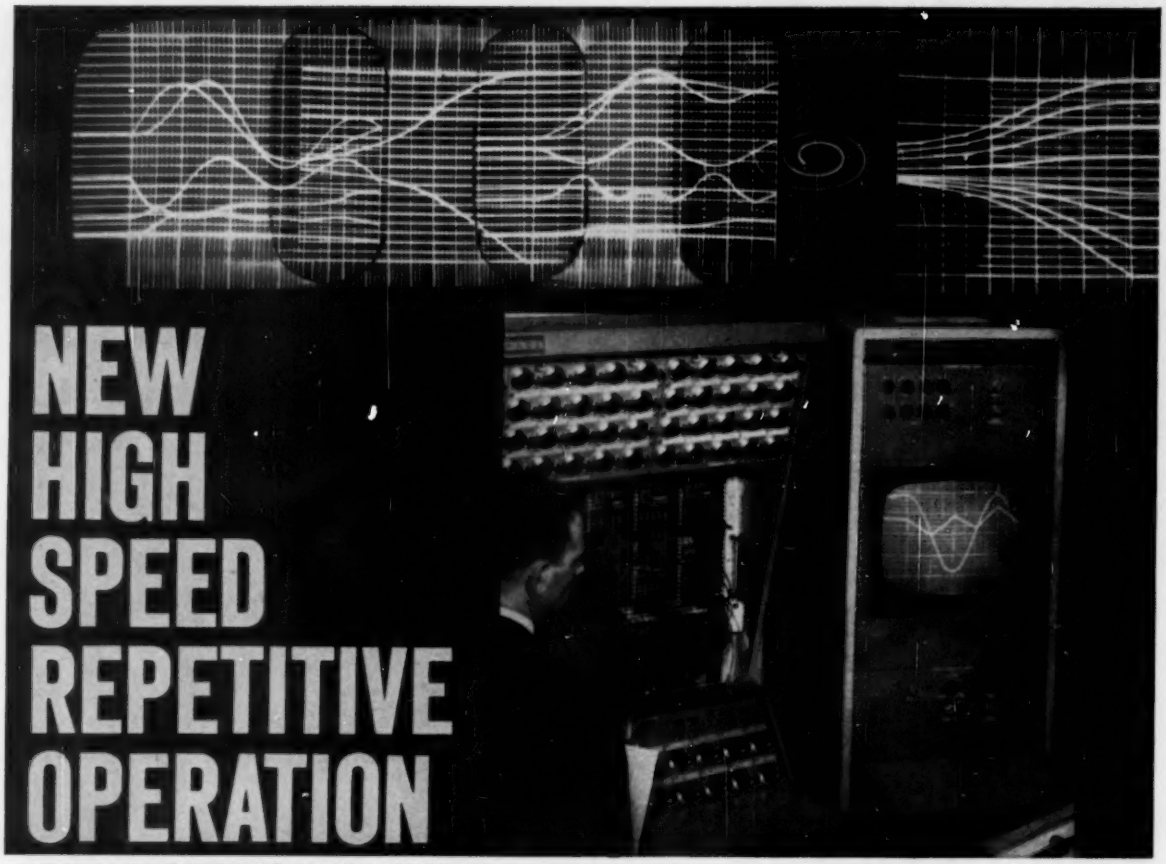


NEW HIGH SPEED REPETITIVE OPERATION DRASTICALLY CUTS ANALOG COMPUTATION TIME

The new EAI high speed repetitive operation system is ideally suited to systems design work because it produces solution repetition rates of 10 to 50 per second with *no loss of real time accuracy.* Used with Electronic Associates, Inc. Model 231R analog computer, it provides instantaneous change from real time operation to high speed repetitive operation by a single control . . . requires no re-patching . . . allows real time recording of selected solutions.

This newly developed system for PACE® analog computers can be used as a highly accurate and extremely versatile method for solving a variety of computational problems with greater speed and precision. It is an especially useful engineering tool for design problems involving simulation of servomechanisms, optimization of systems, solution of boundary value problems and mathematical 'model building'. High speed repetitive rates insure rapid approximation of optimum system parameters for control systems and determination of stability regions.

Outstanding features of the EAI high speed repetitive operation system include—

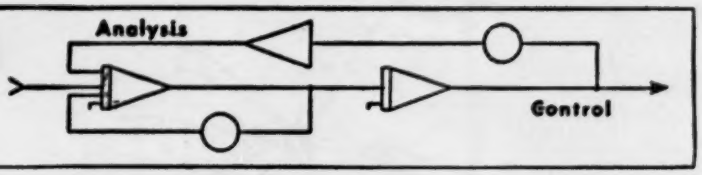
- **solution repetition rates of 10 to 50 solutions per second**
- **precision crystal oscillator control of display unit timing**
- **computer repetitive rate remotely slaved to precision crystal oscillator**
- **switched control of compute time with continuous control between steps**
- **electronically generated display grid . . . constant for repetitive rates**
- **simultaneous display of up to eight variables**

For complete details write for Bulletin AC-6034 describing the new EAI high speed repetitive operation system.

EAI ELECTRONIC ASSOCIATES, INC. *Long Branch, New Jersey*

CIRCLE 74 ON READER-SERVICE CARD

The SIMULATION COUNCIL Newsletter



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Bits

The Newsletter this month is devoted exclusively to reporting the January 1960 meeting of the Midwestern Simulation Council. We have no "Letters" (perhaps because we are not home*) and our only "Thot" concerns having to meet a Newsletter deadline while on vacation, and is therefore not printable.

The subject of the Midwestern meeting was "Tying Physical Equipment Into Analog Computers", and the speeches reported are "An Analog Computer in a Power Dispatching System" by *P. J. Hermann*; "Functional Physical Systems Currently Being Used With Analog Computers" by *Bill Parker*; "Wind Tunnel Instrumentation Using Analog Computers" by *Dick Thomas* and *Jack Mauersberg*; and "Simulation to Obtain a Systems Measure of an Air Duel Environment" by *Ben Gordon* and *A. Alan B. Pritsker*.

Pieces

MIDWESTERN S/C MEETING OF 18 JAN. ON TYING EQUIPMENT TO ANALOG COMPUTERS

"Tying Physical Equipment into Analog Computers" was the topic for discussion at the meeting attended by 37 members of the Midwestern Simulation Council held on 18 January at Battelle Memorial Institute in Columbus, Ohio.

Hermann on Economic Power Dispatch

"The system I'm going to talk about would probably be more accurately described as 'Tying Analog Computers into Physical Equipment' rather than vice versa" said *P. J. Hermann* (Goodyear Aircraft Corporation, Akron, Ohio) by way of introduction to his talk on "An Analog Computer in a Power-Dispatching System."

As first speaker on the program *P. J.* described the GEDA EPDC (Economic Power Dispatch Computer) and the Power Dispatching system of the Ohio Edison Company. The latter is the electrical power utility serving much of northeastern Ohio. The dispatcher's office is located in Massillon, and it is from this location that control of the entire System is exercised.*

Functions of the GEDA EPDC are:

(1) To compute static power generation curves for the system for various conditions of operation, costs and efficiencies.

(2) To receive information on power generation conditions in the system, compute the most economical generation configuration, and provide the dispatcher with dispatching signals.

(3) Having produced the foregoing information, to drive control servos which automatically send out dispatching signals to the generating units in the system.

"We are primarily interested in the third function but, since putting the computer in control is practically incidental once the system and the computer have been developed, I am

*Your Ed. and Secretary are spending their vacation in New Orleans. The oysters are fine, the friends are sublime, but the weather is *Not* numero uno!

*Milt Aronson has abstracted the original paper on this system—see pages 1304-05.

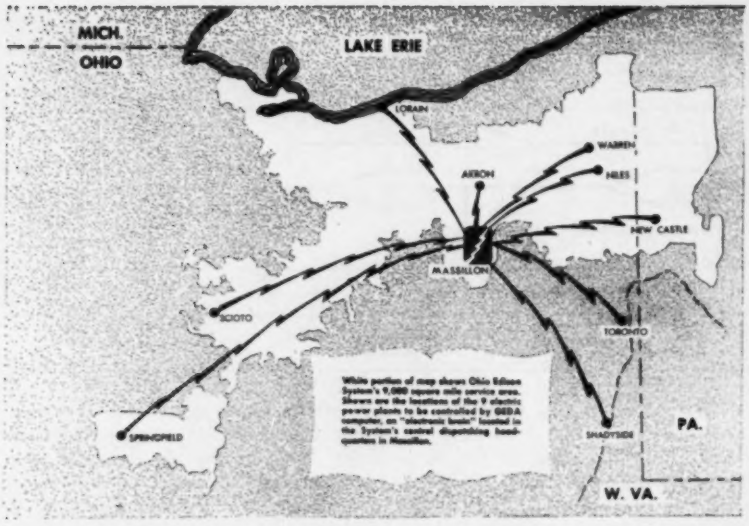


FIG. 1. OHIO EDISON system's 9000-sq-mi service area. Nine power plants are controlled by computer at Massillon.

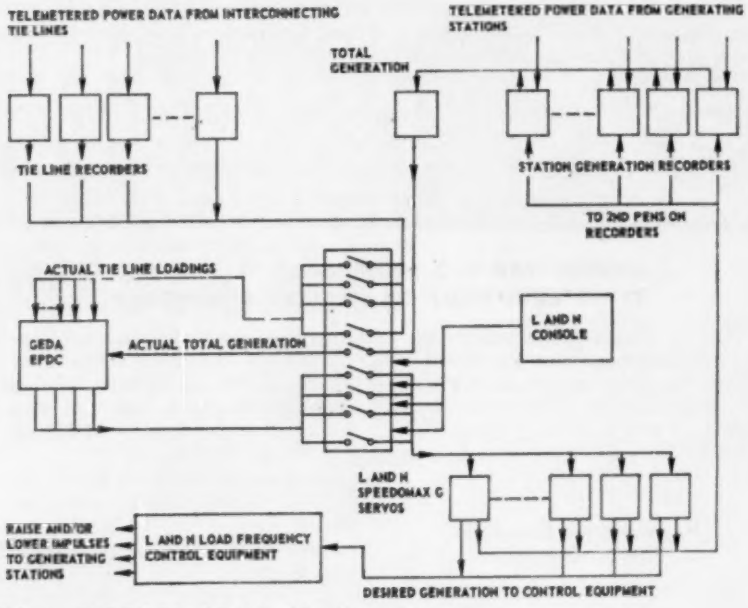

TELEMETERED POWER DATA FROM INTERCONNECTING TIE LINES
TELEMETERED POWER DATA FROM GENERATING STATIONS
TOTAL GENERATION
TIE LINE RECORDERS
STATION GENERATION RECORDERS
TO 2ND PENS ON RECORDERS
ACTUAL TIE LINE LOADINGS
GEDA EPDC
ACTUAL TOTAL GENERATION
L AND N CONSOLE
L AND N SPEEDOMAX G SERVOS
RAISE AND/OR LOWER IMPULSES TO GENERATING STATIONS
L AND N LOAD FREQUENCY CONTROL EQUIPMENT
DESIRED GENERATION TO CONTROL EQUIPMENT

FIG. 2. BLOCK DIAGRAM of load control system.

going to review the whole system," said *P. J.*

Fig. 1 shows a map of the Ohio Edison's Service area in northeastern Ohio. Nine power generation stations are shown for the system. At each of these there are more than one generator sible for power generated in Lorain to supply peak load requirements in the area around New Castle.

Since long transmission lines result in a substantial increase in transmission losses, and resulting inefficiency of the system, it is desirable to reduce the length of the transmission paths. But that isn't the whole story. The efficiencies of the power generating units also enter the picture. Some were installed more than 50 years ago, while others are less ating unit, for a total of about 50 such units in the entire system. In many locations (such as Akron with its rubber shops, and Warren and Youngstown, where there are a number of steel plants) the load on the system is considerably more concentrated. To supply the system and to insure that locations of load concentrations are adequately supplied, the entire power generating system is tied together through a network of power transmission lines. Thus it is posthan 10 years old. The newer machinery is more efficient, so it may be more economical to produce power with the newer units even when this makes it necessary to use longer transmission lines.

Finally, there is the factor of fuel costs. These vary with the location of the plant. Shadyside and Toronto are considerably closer to coal mines, so we may expect fuel costs there to be less than at the more remote generating plants.

The literature indicates that for a power system to supply its load most economically the incremental value of the power delivered to the load center by each station must be equal. Thus if the demand at some point in the system is increased, that part of the increase supplied by each of the stations should cost the same.

Having explained the problem, *P. J.* then went into the mathematics and other details of its solution which, he said, he gleaned from the literature and did not understand completely himself.

Neither do we, but it seems that somehow the cost of the total system power actually being generated at every instant is computed. Chances are, however, that the computed best possible value does not exactly match the actual system power generation cost. If not, it means that there is an incorrect value for the incremental value of power in the system. It is then a simple and quite logical step to go from generation of signals that indicate to a dispatcher how to distribute the power generation, to directly operating servo equipment to automatically send dispatching signals to the various stations.

When the computer is actually controlling the system, the error signal produced is used to drive the power-cost servo which adjusts the value in the servo-multiplier feeding into each station simulator. The servo drives the computer so that the error is reduced toward zero. When it reaches zero the output of each station simulator is a signal representing the amount of power which that particular station should be putting into the system for most economical operation.

Fig. 2 shows a functional diagram of the system. At the upper right telemetered signals from the various generating stations drive Leeds & Northrup recorders which have repeating slidewires in them. Signals from these recorders are then collected and displayed on a Total Gen-

eration recorder, which also feeds into the computer.

At the upper left you see that telemetered signals representing tie-line power are displayed and retransmitted to the computer. These tie-lines are connections made between the Ohio Edison Company and other adjacent power companies. In times of loading imbalance in a given system, the various facilities buy and sell power among themselves on an almost automatic basis. The effects of tie-line loading are computed in almost exactly the same way that the system generation effects are. However, they may be both positive and negative. "The cost of power delivered to another generating system through a tie-line is quite well represented by the computer, and I have heard rumors that the computer results may therefore be used in billing," *P.J.* said.

In addition to tie-lines, the computer takes into account loading conditions known as non-conforming loads. These are loadings on the power generation system which can drastically disturb the location of the centroid, or "c.g.," or load center of power usage in the system.

The outputs of the computer are used to drive L&N Speedomax G servos, which in turn send out the control impulses to the various generating stations. These servos already existed in the facility, and it was a relatively small job to have the computer operate the system.

Stability is no problem; the computer is so much faster than the rest of the system that it produces practically no phase lag in the closed loop.

In Fig. 3 we have plots of station power generations as functions of total system power showing the effect of higher efficiencies at some stations than others. You can see that Station 8 increases its power output at a high rate as system demand increases until the maximum that Station 8 can produce is reached.

On the other hand, Station 2 is putting out a minimum of power until the very last, when the maximum capacity of the system is approached. It appears obvious that Station 8 is the most efficient station in the system and Station 2 the most inefficient. The computer has these efficiency factors built in and calls for the greatest increment of power to come from the most efficient station.

Note that none of the stations is ever reduced to producing zero power.

Fig. 4 is a picture of the GEDA EPDC at Massillon.

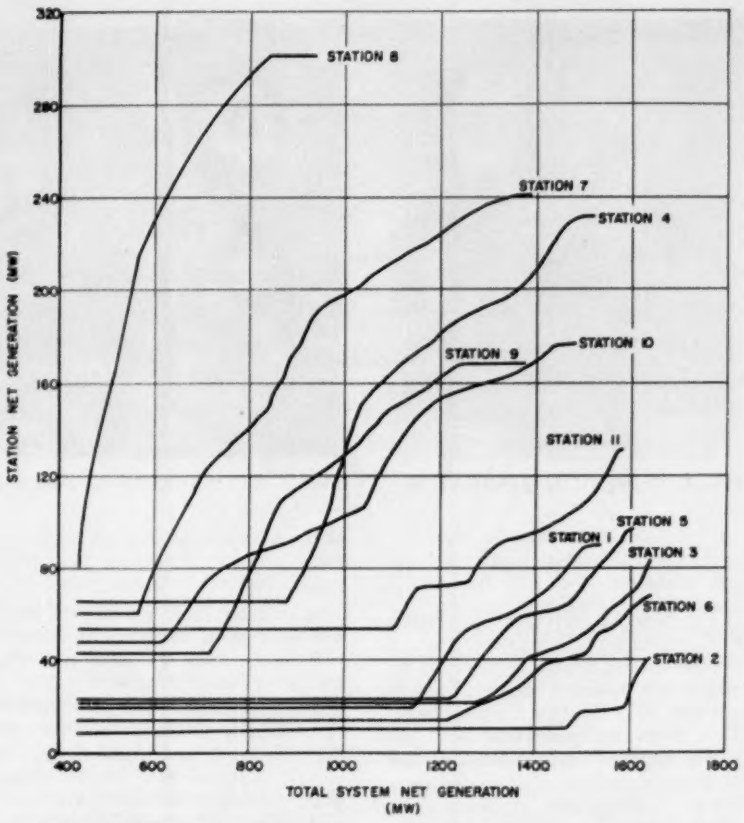


FIG. 3. OPTIMUM division of system load among generating stations.

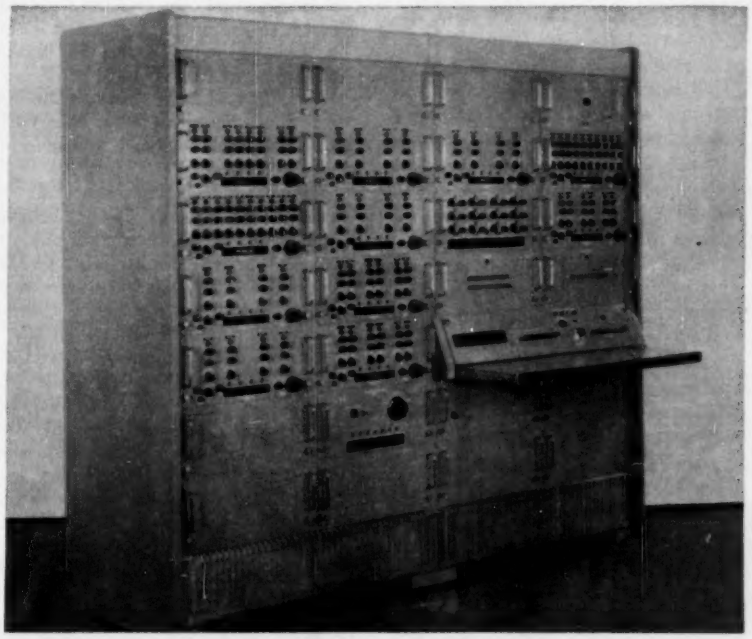


FIG. 4. GEDA control computer.

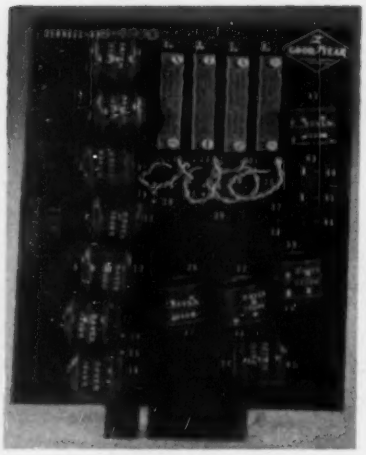


FIG. 5. FUNCTION GENERATOR.

FIG. 6. BILL PARKER (standing) and L. C. FARGEL (seated) at one console.

Fig. 5 is an individual generating unit simulator. Note that it is a printed circuit board. Diodes and resistors are mounted on the board to provide DFG function for the Power-Heat Rate function. These units are easily removed and replaced so that it is quite easy to change the computer characteristics representing a given generating unit and station.

Following *P.J.*'s talk *Bert Johnson* (Electronic Associates, Inc., Mt. Prospect, Ill.) asked, "Is the Ohio Edison Company using or planning to use any other such system? Is it proving to be a useful tool? Would they use this device to evaluate a new station?"

"I would assume," *P.J.* answered, "That whenever they plan a new station they will put it on the simulator to find out what its effect will be.

"Very shortly after they put the system into operation there was a rather bad snow storm. One transmission line fell down and there were quite a few sparks flying around. This was a real emergency situation. Company officials wanted to know immediately how best to produce and distribute their power. They put the problem on the computer and solved it almost immediately. They were very happy with these results."

Joe Wilson (Rock Island Arsenal, Rock Island, Illinois) asked, "If they had a significant shift in the load center, what time would be involved to compensate for that?"

P.J.: "All I really know is that the response of the computer is so fast relative to the rest of the system that stability is no problem. I believe that the computer itself would produce a new solution in less than one minute.

Vern Larrowe (Willow Run Research Center, Ypsilanti, Mich.) asked whether there was some kind of restriction or protection against what the computer can do when it is in control of the system. "In case a computer malfunctioned and gave incorrect signals, what would happen?"

"I am sure there are some safeguards," *P.J.* answered. "I don't know all of them, but one is incremental cost. This is plotted and displayed. The dispatcher can watch it, and if something starts going wrong, the incremental cost is going to build up. There are other protections within the computers—overload lights and things of that sort."

Bill Field (Union Carbide Olefins Co., South Charleston 3, W. Va.) wanted to know the basic precision of this calculation.

P.J.: The basic units are diode function generators, and I believe some servo multipliers and one or two electronic multipliers. These would have the basic accuracies that we are used to in the L-3, N-3, and A-14 lines, probably better than 1%."

Bruce Baldridge (Bailey Meter Co., Cleveland, Ohio) asked if Goodyear was going to make any more of these.

P.J.: "No. When a company like L&N is going to produce all the rest of the transmission recording and control system, and then throw in the computer as sort of an incidental feature, we can't hope to compete."

Joe Wilson recalled *P.J.'s* remark that this computer might be used for billing.

P.J.: "I don't know whether this is really true or not. I have heard rumors, but it doesn't sound likely to me. I can't quite imagine the accounting department going for an analog computer!"

Bill Parker on Tying Airframes To Analog Computers

Bill Parker (North American Aviation, Columbus, Ohio), who operates one of the largest labs (Fig. 6) tying simulated airframes into analog computers, next told of "Functional Physical Systems Currently Being Used with Analog Computers."

"Functional mockups . . . which accurately simulate actual operational loads are essential to the development of new control systems" states a brochure on the NAA Flight Simulation Lab which Bill passed out.

The designs of complex electro-mechanical and electronic control systems of modern high-performance aircraft are optimized at North American-Columbus through test and analysis of full-scale operational mockups. These mockups are instrumented to present a complete range of data on the responses of the systems and components being tested to actual flight conditions and dynamic loads, (simulated with weights, springs, dynamic pressures, etc. The data thus obtained in the form of voltages are fed directly into a 400-some-odd amplifier analog computer for continuous analysis. Additional simulations can be set up within the computer either through special circuitry or by using magnetic-tape recordings from actual flight tests. Thus a program of unusually wide scope can be accomplished far in advance of production and flight testing.

FIG. 7. G-SEAT cockpit.

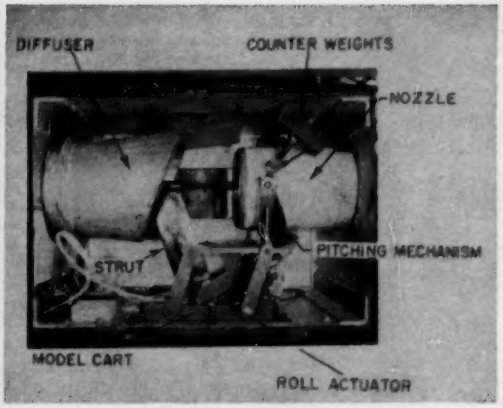


FIG. 8. HYPERSONIC test cabin with model inserted.

The laboratory can provide all instrumentation for control mockup tests, construct and test breadboards of electrical and electronic systems, make autopilot and cockpit presentation studies, and test guided missile controls and preliminary guidance systems.

To incorporate pilot responses into the data being analyzed the "G-Seat"—a specialized dynamic flight simulator which can accurately simulate the feel and handling qualities of a plane—has been developed. The illusion of flight is provided by optical presentation, using a projector which throws pictures of the rear portion of an aircraft onto a screen several feet in front of the seat. The image can be made to reproduce actual aircraft motions through a gimballing arrangement in the table which supports the projector, with the gimbals controlled by signals from a magnetic tape recording of an actual flight.

Fig. 7 shows the G-Seat.

The pilot in the G-Seat flies a tail chase on the projected airplane. As he moves his control stick, signals from a computer move the seat and subject the pilot to G forces exactly corresponding to those of the aircraft being simulated. Signals independent of the pilot's input can be fed to the seat to simulate effects of rough air or other sudden forces. This equipment can be configured to simulate any aircraft for which the aerodynamic equations of motion can be obtained. The aircraft can be simulated at any flight condition, and conditions can be changed rapidly.

By using both computer and hardware, either separately or simultaneously, it is possible for the Servo Lab to carry on a wide variety of programs. Some of the programs already conducted include tracking of missile trajectories, simulated subsonic and supersonic aerodynamics with five degrees of freedom, simulated structural flexibility, and simulation of airplane control systems and autopilot equipment.

The installation has been in operation about three-and-a-half years. No accidents to date, but they do have a hazardous condition where transients can be sent into the physical system being driven hydraulically. The total number of amplifiers as of 1960 is slightly over 400. There are eight six-channel recorders. The area in which the computer is located is an L-shaped room inside another room containing the hydraulic equipment.

The Functional Mockup is an angle-iron mockup which is neither pretty nor light. "They'll never get it off the ground." Synchros are put on the front of regular analog computer servo-multipliers and used to operate the mockup instruments. Position transducers on the mockup are operated at 400 cycles to produce signals which are demodulated, scaled and fed into the analog computer to close the loop.

A flight tab made by California Technical Industries is also tied into the computer. This complete system, with information available from wind-tunnel tests, allows very complete and accurate simulation of actual flight tests—which it has been estimated cost about $10,000/hr!

In answer to a question following Bill's talk, Chuck Walli said that on occasion they had taken flight-test data and closed the loop with the computer to check on wind-tunnel data.

Bill then told of a case in which data from a particular flight test was used to try to simulate accurately the conditions of flight. Without any hardware whatsoever in the loop, the computer study indicated that if just a one-inch strip was added to the T2J rudder a yawing problem would be stopped. Then they tried it—made an actual flight test—and that was the end of the problem!

Mauersberg on 12" Hypersonic Wind Tunnel

Jack Mauersberg (Ohio State University, Columbus, Ohio), the third speaker on the program, told about work which he and his colleague, Dick Thomas, have done at OSURF.

The OSURF is a non-profit Research Foundation making use of the personnel and research facilities of Ohio State University to conduct research for industry, government, and other interested sponsors. The Aerodynamic Laboratory is a division of the Department of Aeronautical Engineering with a permanent staff of engineers, mechanics, and technicians as well as temporary personnel consisting mainly of students, graduate and undergraduate. In employing students the Aerodynamic Laboratory is in part fulfilling the principal goal of the University—education. Training of scientists and engineers by providing opportunities to take part in current research projects is felt to be perhaps as valuable as the knowledge gained from the research itself.

The principal kind of apparatus used at the laboratory is the wind tunnel. Available are tunnels for practically the entire regime of fluid flow from subsonic through transonic and supersonic to hypersonic flow.

Because of widespread current interest in guided missiles, re-entry vehicles and satellites, most of the recent wind tunnel testing at the Aero Lab has been in the 12-inch hypersonic tunnel. "Twelve-inch" refers to

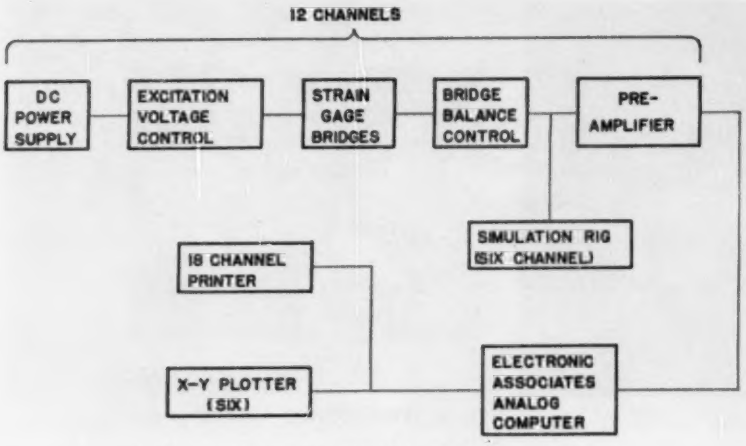


FIG. 9. BLOCK DIAGRAM of force recorder.

the exit diameter of the nozzle used to accelerate the air to speeds from six to 14 times the speed of sound. Fig. 8 shows the test cabin of this tunnel together with the model support system. Air heated up to 2000°F passes from the nozzle to the diffuser, or from right to left in the picture. The model is attached to the end of a cylindrical, hollow, steel rod known as a sting. Near the end of the sting flat surfaces are machined in the rod, and strain gages are attached to these surfaces. This section is known as a force balance, and it is here that aerodynamic loads on the model are sensed and voltages proportional to these loads fed to the computer.

Models used with this strut and balance holder may be pitched or rolled remotely. The model positioning control center is located next to the computer.

There are four sets of strain gages measuring forces at different locations in this "four-component balance".

Fig. 9 is a layout illustrating the use of the wind-tunnel balance with the analog computer and associated components. The strain-gage bridges in the balance are energized by a C.E.C.-type 3-132 low-voltage d-c power supply. This is a very stable voltage source supplying up to one ampere current from 0 to 15 volts. Power limitations of the gages due to the manner in which they are used limit the excitation voltage to 4-6 v. A C.E.C.-type 8-108 bridge balance is used to control the bridges in the balance. This appears in the figure as excitation voltage control and bridge balance control. This unit has an eight-channel capability. It is possible to adjust the excitation voltage on each bridge, to balance residual signals from each bridge, and to reverse polarity for each bridge. With the balance described and current excitation voltage, each bridge produces a usable signal of about 1½ mv. per pound force. With maximum forces under 20 pounds, it can readily be seen that considerable amplification is needed to get a usable signal.

The outputs of the strain-gage bridges are fed into Doelcam Model 2HLA-4 Selective Range d-c amplifiers to boost the signal level. These pre-amplifiers are both stable and accurate, with the gain varied by plug-in units. If other signals, like pressure-transducer outputs are used in the computer program, these outputs are introduced into the computer by these pre-amplifiers. At present there are 12 pre-amps available for providing inputs to the computer.

An Electronic Associates Model 16-31R basic analog computer group forms the programmed operations to reduce data obtained from tests. Additional equipment has been added to the basic group, so that now there are:

- 32 summer operational amplifiers
- 8 summer integrator operational amplifiers
- 60 potentiometers
- 2 servo-resolvers
- 8 servo-multipliers

Also added to the system were six EA Model 1100D-XY plotters to provide on-the-line data plots, which have proved very useful.

A Hewlett-Packard Model 560-A high-speed printer provides a record of any desired voltage appearing in the computer program. 270 milliseconds are needed to print one channel of information. When the printer is used with an automatic stepping switch, up to 18 selected voltages can be printed in less than five seconds. After the eighteenth voltage has been printed, a signal can be sent to the model pitch motor to change the pitch angle by a predetermined amount. Simultaneously a time delay is introduced to prevent the printer from cycling through again until the model has reached the desired position. It is thus possible to accumulate a relatively large amount of data in a short time, and the plotters enable observation of some of the dynamic phenomena which may occur.

One interesting piece of equipment added to the computer system is the simulation rig. This is a simple apparatus using a computer integrator amplifier to supply voltage to a voltage-dividing network. This network is designed to produce voltages similar to those produced by the strain-gage bridges in a force balance. These voltages are supplied to the pre-amplifiers and thus provide a standard problem to be used in checking the entire data system.

An analog computer program for the reduction of wind tunnel force balance data is a simple one which requires no unique features in programming. The basic problem is the solution of a system of simultaneous linear equations, the number of equations being determined by the number of components or strain-gage bridges in the balance. Each bridge output is a function of the force it is designed to measure, and also a function of all other forces applied to the balance. The bridge outputs caused by these other forces are known as interactions, and must be accounted for in the calculation of the true force. Since each force component output is a function of all component outputs, the equations for determining the force components are set up in the form of a matrix. By careful balance design the primary bridge output voltage as well as its interaction output can be made linear with respect to the applied forces. All the bridge outputs are determined by a weight-hanging calibration of the balance. Since, as already mentioned, these outputs are all linear, the coefficients or slopes can be set in the equations using the computer potentiometers. Using a number of closed loops, the computer is programmed to solve the equation system for the force components on the wind tunnel model. Additional computer programming is used to calculate other desired parameters, like

lift and drag coefficients, and in some instances to transfer reference axes.

Data accuracy is a topic of interest to many, particularly aerodynamic testing groups of aircraft and missile companies. While computer component accuracy can be readily specified, this usually isn't sufficient to satisfy anyone when it comes to using these components in diverse applications. An accuracy study was undertaken at the Aerodynamic Lab to check the accuracy of the analog computer in determining aerodynamic force coefficients on a wind tunnel model. Voltages from the computer reference power supplies were made equal to voltages produced by the balance bridges during an actual test run, and introduced into the initial computer operational amplifiers. Outputs from the computer were recorded on printer tape and the results compared with hand-calculated results obtained for this test.

By far the majority of the points calculated showed less than 1% error based on the readings. This, it is felt, is quite good.

Because of its versatility the analog computer seems well suited to the needs of the Aerodynamic Laboratory. Its use in differential equation and simulation studies is well known, and it has proved that it can provide usable results in wind-tunnel force model testing.

Following *Jack's* talk *Professor Rideout* (University of Wisconsin, Madison) asked, "Is the d-c supply to the strain-gages preferable to an a-c supply?"

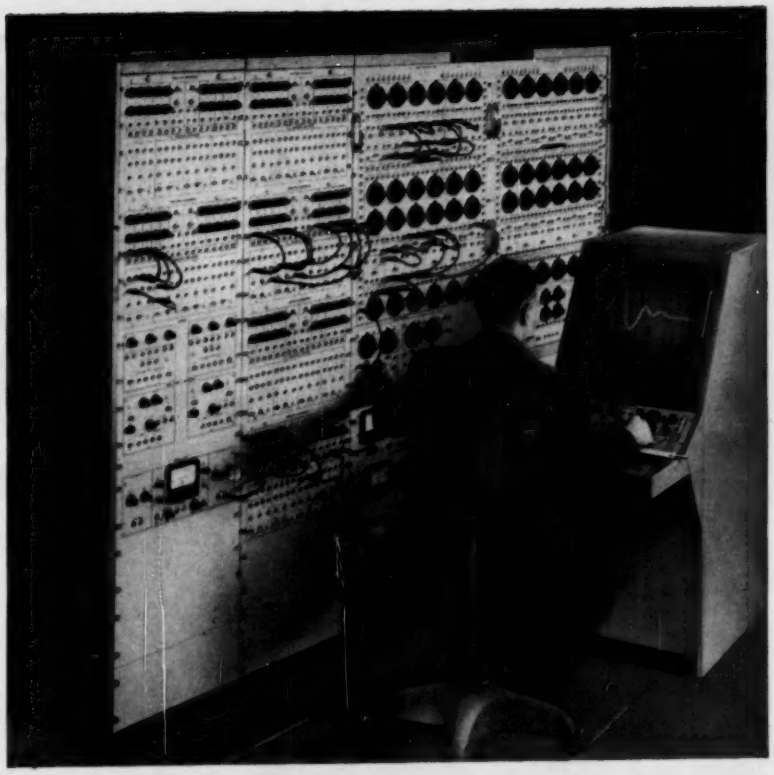
"That's a matter of opinion," *Jack* replied. "Before the installation of our analog computer we used a-c excitation and found no particular problem. But for the analog computer we need a d-c signal."

Bill Field (Union Carbide): "I would imagine that a-c excitation would minimize difficulties with drift, but then to get a computer input signal you would have to demodulate or rectify. This might introduce a different kind of error, so probably the choice of d-c is best."

Gordon and Pritsker on Flight Games

The last talk of the day, billed as "Simulation to Obtain a System Measure of an Air Duel Environment" by *Jack Wetherbee* was actually presented by *Ben Gordon* and *Al Pritsker* (all of Battelle Memorial Institute, Columbus, Ohio).

"We have a simulation facility designed to simulate one portion of the air defense system," *Ben* said. There



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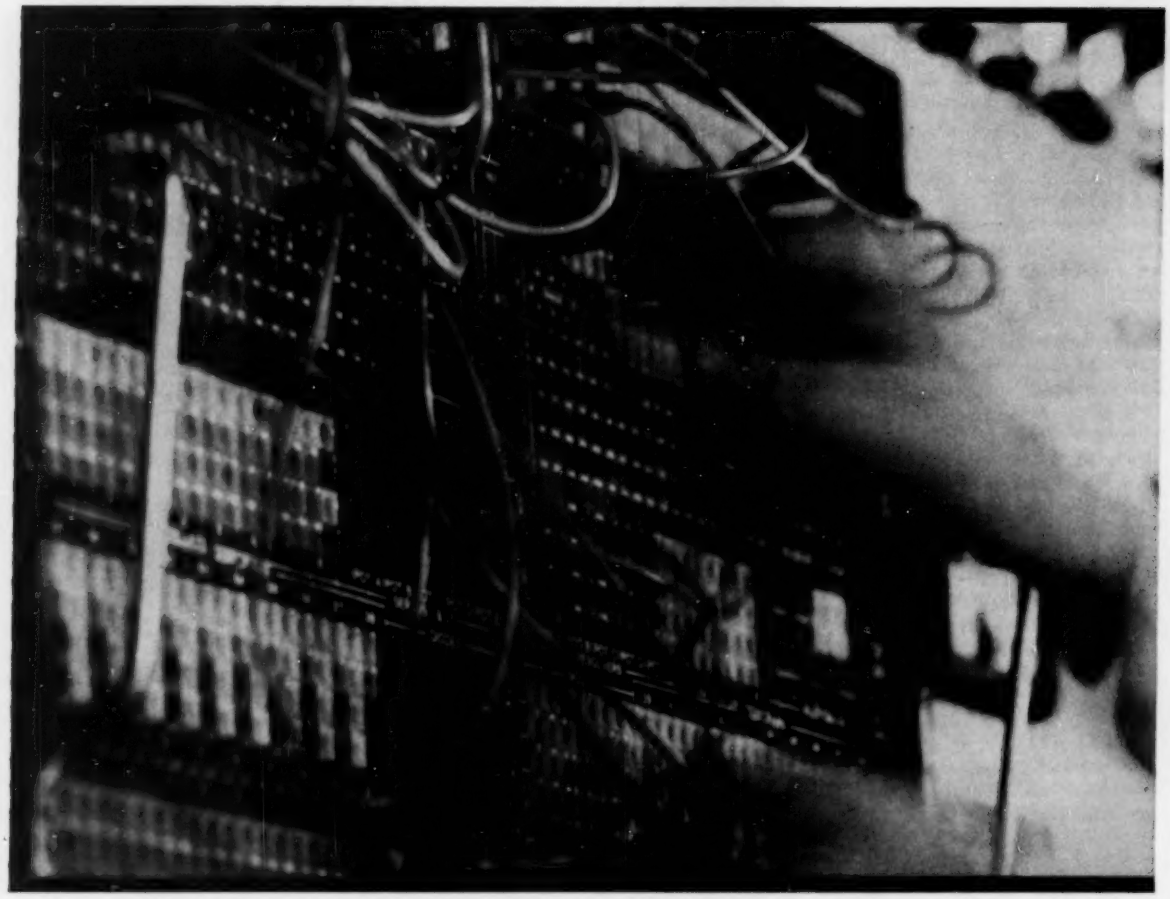

A MAJOR BREAKTHROUGH IN PROBLEM SOLVING

*DYSTAC: Dynamic Storage Analog Computer, developed by CSI, incorporates high-speed repetitive capabilities with dynamic storage of analog data to an accuracy of 0.01% and with a time-base accuracy of ±0.5 microsecond. This development has tremendously increased the versatility, economy, and speed of solution associated with analog computers.

DYSTAC provides unique time-sharing of computer components and high speed reiterations. These features make possible economic and rapid solution of complex problems that have required too many computer components or too long a solution time to be considered practical for either digital or analog techniques. Different combinations of this new development readily solve problems in four broad categories.

- Sequential calculation, as encountered in the distillation problem. Here, successive solutions to algebraic matrices are obtained from cycle to cycle at a repetitive speed of 60 cps until the problem is solved.
- Definite integral calculations. Varying definite integrals are evaluated from one cycle to another and held in memory for the successful solution of optimization problems.
- Rapid evaluation of multiple integrals. This technique can be employed for the solution of partial differential equations.
- Transient problems and difference-differential equations are solved with continuous memory.

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is an attacking bomber carrying ECM (electronic counter measures) and the defense system's radar, sending up radar pulses and getting radar return. This information is placed on a radar scope read by a human operator. The information is then transmitted to the interceptor pilot by voice or some other method of communication. The interceptor then flies as directed until the proper time when he uses his AI radar to complete the intercept.

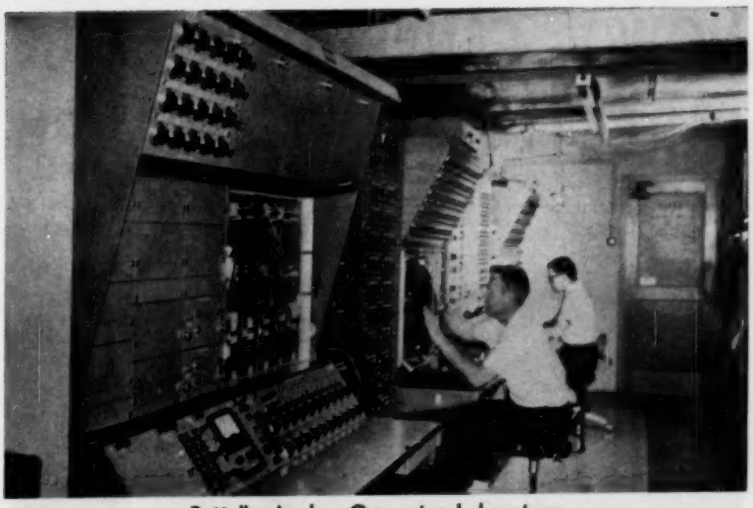
There are many ways in which this system could be studied; many levels at which it could be simulated. For example, the Air Force studies it by actually flying missions. They substitute our bombers for enemy bombers, but everything else is the actual hardware: in such studies there is no simulation of any kind.

They also study the system using a radar simulator. They eliminate the actual bomber and interceptor and substitute the scope presentations. The scope operator then communicates with simulated interceptors whose simulated targets appear on the scope.

The next step in simulation would be to remove the operator and scope from the air defense site, and bring them into the laboratory. There you would have a simulated radar system with a simulated radar scope being observed by the radar operator. The bomber and interceptor flights would be simulated, but the human being would still be in the system, observing data on the scope and transmitting the voice information.

The final stage of simulation would be computer simulation of the entire system, including the human.

At Battelle they are simulating the bomber flight and simulating the radar, but still have the human operator in the system. There are many factors which could be varied in such a system: the type and power of the ECM being carried by the bomber, capabilities of the radar, including any electronic counter measures; the type of communication; even countermeasures affecting the communication between the ground and the interceptor and its radar, including counter measure capability in the bomber against it. In the Battelle system they have merely added as variables the type of electronic countermeasures available for use against the radar. The capabilities of the interceptor and bomber are always kept constant; they assume that neither the AI radar nor the communication link is being jammed. This system which is being used to evaluate counter measures and counter counter measures, could also be used to evaluate various types of ECM or bomber tactics, or the effectiveness of various counter measures involving different types of bomber maneuvers. The system could even be used for operator training.



Battelle Analog Computer Laboratory

BENJAMIN B. GORDON was born in Cleveland in 1926. He received his Bachelor of electrical engineering in 1952. He has been employed at Battelle since 1951, and has done work in instrumentation, electrical engineering, systems engineering, and analog computer simulation. He is presently Project Leader directing the activities of the Analog Simulation Laboratory at Battelle.

A. ALAN B. PRITSKER was born in Philadelphia in 1933. He has a B.S. (electrical engineering), M.S. (industrial engineering), and has completed requirements toward the Ph.D. degree in industrial engineering. He joined Battelle Memorial Institute in 1956 and is Assistant Chief of Battelle's Systems Engineering Division.

Ben went into some detail concerning the method of obtaining a realistic scope display and the rest of the electronics involved in the system. The analog computer is used to reproduce the bomber path, and voltages which are functions of the echo area, which changes with the angle of looking at the bomber, the range of the bomber, and its position within the antenna pattern.

The operator observes the scope and by voice gives data to a key punch operator who punches it into a card. Concurrently the actual range, azimuth, and time are punched into the same card. At the end of a run there is a stock of such cards for each particular type of ECM, power of ECM, and subject observed.

They studied 15 different types of countermeasures, with 15 subjects to eliminate subject difference in determining the effectiveness of the countermeasures. Fifteen different orders of presentation were used to eliminate the effects of learning.

The simulation as set up can be used only for a single target, single radar set. By adding equipment like that already in use, they can increase the equipment's capabilities to handle more than one bomber and more than one flight. And because the bomber is simulated by an analog computer, they can introduce a man to control the bomber's path. The bomber can then maneuver, according to information available to it. The simulation of a portion of the air defense system can thus be expanded as desired.

Al Pritsker then took over to explain

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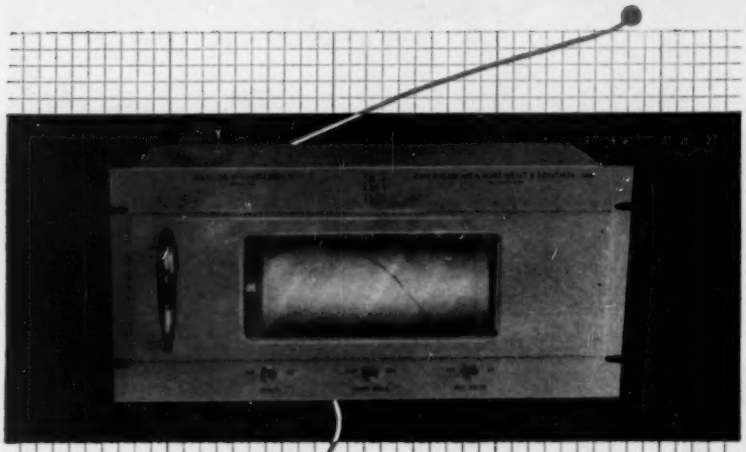

The Model 750 Analog Programmer — new from AM&C — provides the simplest and most reliable method yet devised for generating arbitrary functions for analog simulators, computers, or process controllers. It gives a continuous voltage output directly proportional to any single-valued function (Y) drawn in conductive ink directly on graph paper as a function of time (X). Accuracy is ±0.5% and full-scale response is less than 10 microseconds.

The Analog Programmer consists basically of a chart-supporting drum and potentiometer roller. A portion of the externally applied potentiometer reference voltage is picked off where the drawn curve intercepts the potentiometer. Thus, at any specific instant of time (X), the output voltage is proportional to the ordinate value (Y) of the drawn curve. Synchronously-motor driven at pre-selected speeds, an infinite variety of program time conditions are available. Drum can also be servo-motor driven, thus making (X) a function of an independent variable.

Programmer is unequalled in flexibility and convenience for missile flight simulation, structural testing, linear programming of non-linear function, and automatic control of industrial operations and processes.
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the use of the data collected on the punched cards. With it they use an IBM 650 computer to actually simulate the flight of the interceptor based on the *observed* simulation of the bomber. And with the true information concerning the bomber track, plus time, they can determine the interceptor's probability of killing the bomber: this is considered the ultimate measure of system performance. In the past various intermediate measures were used—the scan ratio, how many times does he see the target, when does he see it, and so on. They wanted to find out how well these measures correlated with probability to kill.

The actual simulation of the air duel between the bomber and the interceptor was broken into two phases so that it could be accommodated on the 650; a vectoring phase in which the interceptor is directed by the human operator to a point in space where airborne radar systems or the human pilot can take over; and the second phase, in which the probability of killing the bomber is determined. This involves a climb to altitude, projected ground distance during climb, distance the interceptor must fly at bomber altitude before turning onto its final leg course, a turning phase in which the interceptor must turn in order to make a specific type of collision course with the bomber, etc., etc.

After all this, needless to say, the interceptor's position would not necessarily correspond to the one prescribed by the human operator, due to aerodynamic limitations. This leads to some iteration; after the next time interval, has the interceptor reached an acceptable position? If so, has the interceptor reached the roll-out point, the point at which the interceptor completes its turn. Many models of air defense systems start at this point. They assume a probability distribution at the roll-out point to determine the possibility of kill from that point in. Therefore the Battelle people wanted to know if there is any correlation between the errors at roll-out, and the probability of kill. After running the model several hundred times, they found there wasn't any.

It is interesting to note that during the detection phase the computer is asked, "Has the AI radar system of the interceptor or has the pilot detected the bomber on his AI radar?" This probability of detection is computed as a function of the aspect angle between the interceptor and the bomber; as a function of the radar characteristics; as a function of the pilot; and of the scan angle of

the radar system. This is of course a probability function, and therefore must be compared against a random number. If the probability of detection is greater than this random number then the pilot is said to have detected the bomber; if not, the computer goes through the cycle again, another step in time is made, and the computer determines another probability of detection. This same process is repeated until the bomber is detected or a system failure has occurred.

After detection, the computer goes into a lock-on phase, and a number is drawn from a large normal distribution to give the delay due to the fire control system having to lock on.

From the lock-on phase the computer goes into a conversion phase in which it solves the fire control equations to determine whether the interceptor can indeed get into a position to shoot down the bomber.

Since the simulation described involves a stochastic process, it is necessary to run through it many times, to go back and reset the computer, starting again with the original data and go through the same process until the probability of kill is determined.

After *Al's* explanation *Bruce Baldridge* asked, "How long does it take to make one run?"

"The average time for this run was approximately two-and-a-half minutes. Time for the vectoring stage was around six minutes."

Chuck Walli: "Did you use experienced radar operators?"

Ben: "No."

Walli: "If you did use experienced radar operators, do you believe there would be a significant difference?"

Ben: "Significant learning takes place in the brief training preceding the test. The inexperienced operators really do not cause any difficulty."

Pete Novas (International Harvester, Chicago, Illinois): "What about motion and the change of motion in the geometry of attack? Would the digital computer be able to follow any sudden changes which could occur in a true physical system?"

Ben: "We felt that this would be quite difficult on the 650."

Pete Novas: "Would it be possible to handle this if you had a larger digital computer?"

Ben: "We think it would be possible."

Bill Field: "Referring back to *Bill Parker's* paper of this morning, *Bob Kohr* and I have been talking about precision, accuracy, etc. in hydraulic components. Can you give us some idea of hydraulic accuracies as compared to the computer accuracies? For instance, did you find hydraulic dead spots that might cause problems? How good were the hydraulics?"

Bill Parker: "There have been times when we have simulated hydraulic components of control systems when the components were not available. Taking necessary approximations into account, we found that the results were excellent. However, we feel that there is actually nothing to replace the hardware in a real live check."

Bill Field: "Do many of the controls include derivative action, or are they all linear?"

Lou Fargel (North American Aviation, Columbus, Ohio): "Quite a few involved derivative action. If you know something about the system they can eliminate some of the errors."

Bill Field: "We have this type of problem in the chemical field, as do most people in the automotive and aircraft fields. Often in the control of processes, we have to send back information which will control valves, etc. and we are contemplating adding derivative action in hydraulic systems."

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SIMULATION COUNCIL

Calendar of Computer Events

AIEE-AIChE-IRE-ASME
Joint Automatic Control Conference
Kresge Auditorium
MIT
Cambridge, Mass.
9/6-9/60

★ROCKY MOUNTAIN SIMULATION COUNCIL★
Los Alamos Scientific Laboratory
Los Alamos, N. M.
9/16/60

Group meets at 8:45 AM at Lodge lobby. Papers: Control of Nuclear Rocket Propulsion by **R. Mohler**; Kiwi A' Simulation by **E. A. Brown** Notify E. A. Brown (Los Alamos) by Sept. 9 of plan to attend. Include: name, company, citizenship (non-US citizens can attend). Also, if Thur. night room reservations are desired at Lodge, or reservations for Carco air flight from Albuquerque. Rental cars available at Albuquerque or Santa Fe.

★WESTERN SIMULATION COUNCIL★
Edwards Air Force Base, Calif.
9/16/60

AIEE FALL GENERAL MEETING
Morrison Hotel
Chicago, Ill.
10/9-14/60

★MIDWESTERN SIMULATION COUNCIL—EASTERN SIMULATION COUNCIL★
Joint Meeting on Process Control
Union Carbide Olefins Company
Charleston, W. Va.
10/10/60

AIEE-IRE-LSA
Electrical Techniques in Medicine and Biology Conference
Sheraton Park Hotel
Washington, D.C.
10/31-11/2/60

AIEE
Power Industry Computer Applications Conference
Chase Hotel
St. Louis Mo.
11/9-11/60

IRE-PGME
"The Nervous System Components vs Computer Components":
A. S. Hoagland, IBM; K. Killam, Stanford Medical School; C. Rosen, Stanford Research Institute
San Francisco, Calif.
11/24/60

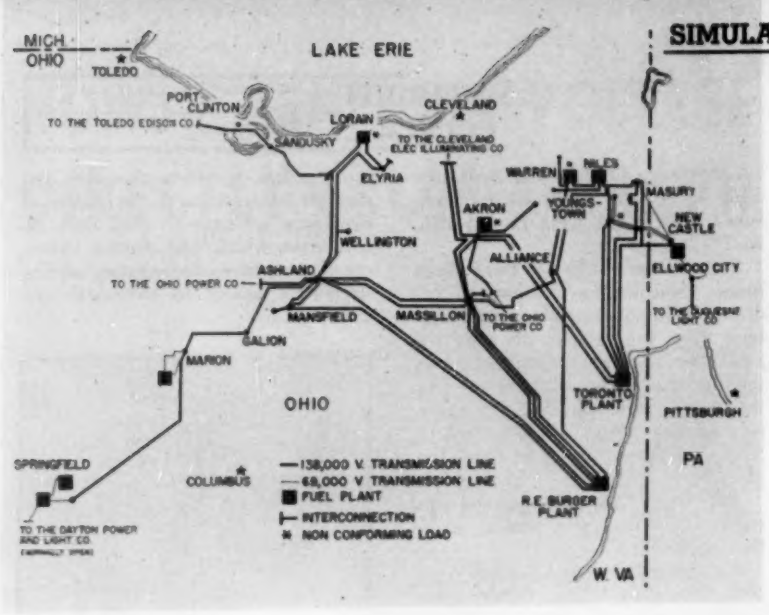
IRE-PGME
"Computer Study of the Nervous System"
W. Clark, MIT Lincoln Labs
Lexington, Mass.
12/8/60

AIEE-IRE-ACM
★Eastern Joint Computer Conference★
Hotel New Yorker
New York City
12/11-14/60

AIEE
Winter General Meeting
Hotel Statler
New York City
1/29-2/3/61

IRE-PGME
"Studies on Use of Computers in Medical Practice and Research"
C. J. Roach and Panel, Medic System Development Corp.
San Francisco, Calif.
4/19/61

AIEE-IRE-ACM
★Western Joint Computer Conference★
Ambassador Hotel
Los Angeles, Calif.
5/9-11/61



Report on a pioneering computer-control system which has been in operation for four years. Many modern generating systems use analog-computer technique. Trend is to use of integral rather than separate computer.

Economic Dispatch

IN the fall of 1956, Ohio Edison placed in service a power dispatch computer manufactured by Goodyear Aircraft Corporation, as an integral portion of its automatic system load-control equipment. This computer is located in the system dispatcher's office at Massillon, Ohio, and continuously determines the desired generation, or output, of each of the system's plants, and feeds this information into Leeds and Northrup load-frequency control equipment.

The computer stores incremental heat rate data for each of 35 steam-generating units of the system, fuel cost data for each of the plants, and incremental transmission-loss characteristic of the system and by use of telemetered information of total system generation and interconnecting tie-line loadings combines all this information to give instantaneous solutions of the coordination equations for the economic dispatch of the system. These solutions are then fed into the load frequency control as the desired generation or "regulating point," for each of the plants.

The system serves a 9,000-square-mile area in northern and central Ohio and in western Pennsylvania. The total load in December 1956 approached 1,500 mw (megawatts). The 11 generating stations are located throughout the system and interconnected with each other and the system's 40-odd major load busses by a network of 138-kv and 69-kv transmission lines shown in Fig. 1.

The computer is being used on automatic control about 95 per cent of the time. During steady load periods the control supervision is switched over to the Leeds and Northrup console and the computer is used to obtain other data useful to the operating and billing departments.

Each day a plot is made on an X-Y recorder of *lambda* (delivered power cost) versus total generation for the particular group of units in operation. Actually, three such curves are plotted: one during the early morning hours, representative of off-peak condition; the second during morning peak period; and a third, if necessary, during afternoon or evening conditions. Also, during periods when the computer is on automatic control there is a continuous graphical record, on an Esterline Angus recorder of *lambda*, the delivered power cost. This record, along with the plots of *lambda* versus total generation, is then used by the billing department.

The computer has been used on several occasions to determine dispatch data for future maintenance outages of equipment, so as to give more accurate information for scheduling of replacement capacity and determination of extra generating expense as a result of the outage.

Abstracts from AIEE Paper 57-143 by R. H. Travers of Ohio Edison, with discussion by Yochelson of Goodyear and S. B. Morehouse of Leeds & Northrup.

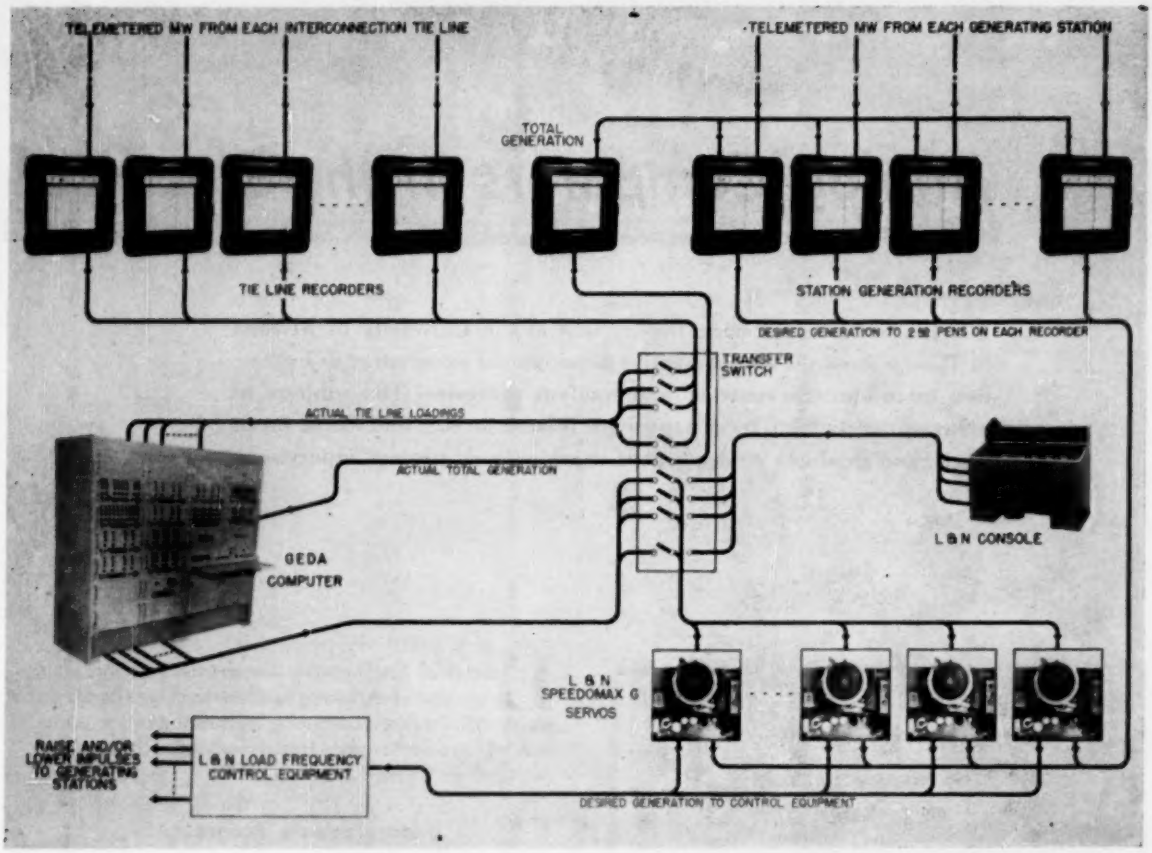

TELEMETERED MW FROM EACH INTERCONNECTION TIE LINE
TELEMETERED MW FROM EACH GENERATING STATION
TOTAL GENERATION
TIE LINE RECORDERS
STATION GENERATION RECORDERS
DESIRED GENERATION TO 2 SB PENS ON EACH RECORDER
TRANSFER SWITCH
ACTUAL TIE LINE LOADINGS
ACTUAL TOTAL GENERATION
GEDA COMPUTER
L & N CONSOLE
L & N SPEEDOMAX G SERVOS
RAISE AND/OR LOWER IMPULSES TO GENERATING STATIONS
L & N LOAD FREQUENCY CONTROL EQUIPMENT
DESIRED GENERATION TO CONTROL EQUIPMENT

FIG. 2. SCHEMATIC DIAGRAM OF CONTROL SYSTEM, with provision for alternate use of Leeds and Northrup console or GEDA computer. Trend is away from use of separate computer.

Leeds and Northrup computing circuits were added to the control equipment at each plant so as to allocate load among the units in the plants in the same manner as the GEDA computer assumes in its calculations. However, system response to regulating demands is independent of the economic allocation and overrides such allocation if necessary.

The computer is supervising the control of the system approximately 95 percent of the time, and in operation has met all expectations as to accuracy and flexibility. Also, use of the computer has eliminated many scheduling chores and has relieved engineering and operating personnel of tedious arithmetic tabulation work which was necessary with the preparation of precalculated dispatches.

Operator acceptance has been quite enthusiastic and it is becoming increasingly more difficult to get them to allow the engineers to use it for other purposes.

The computer has three modes of operation: as a computer, as an aid to the system dispatcher, and as a system controller in conjunction with conventional load frequency control equipment.

In the first mode, data on fuel costs, machine availability, machine and station limitations, line and nonconforming powers, and the total generation requirements, are set manually. Machine characteristics and incremental line losses are represented by printed circuit cards. The computer integrates the data and established the most economical allocation of generation to meet the total system requirements. The results of the computation are read on a built-in digital voltmeter, or an X-Y plotter.

In the second mode, the values of the tieline powers and the required system net generation are supplied to the computer by retransmitting slidewires on the various recorders. The computer follows these requirements and continuously computes the aforementioned quantities.

In the third mode, as a computer-controller, the computer representations of required station net generations, computed as in the second mode, are converted to voltages representing station gross generations. These voltages are applied to the system load-control equipment, which thus is continuously kept informed of the most economical generation schedule and allocates the generation accordingly.

An exact determination of the actual dollar savings resulting from the use of a computer is difficult to make and requires analysis and comparison of a hypothetical loading because of the many uncontrollable parameters involved. We made an analysis before purchasing the computer, considering the four major areas mentioned, and in considerable detail. We found the total installed costs could be regained in savings within a 2-year period.

Analog Computers in the Electrical

The Electrical Engineering Department at the University of Arizona in Tucson dovetails an imaginative development program with instruction in computers, controls, and random processes. The subjects of many undergraduate term papers are related to M.S. and Ph.D. thesis work, and graduate students gain experience as project supervisors.

THE AUTHOR

G. A. KORN

Granino Arthur Korn was born in 1922 in Berlin, Germany. He graduated from Brown University in 1942 and obtained M. A. and Ph.D. degrees in physics from Columbia and Brown in 1943 and 1948, respectively. After wartime service in the United States Navy, Dr. Korn was successively a project engineer with Sperry Gyroscope, head of the analysis group at Curtiss-Wright/Columbus, a staff enginner with Lockheed/Burbank, and a consultant under his own name. Since 1957, he has been a professor of Electrical Engineering at the University of Arizona in Tucson, where he teaches courses on electronic computers and communications theory.

Together with his wife, Theresa M. Korn, Dr. Korn is author of **Electronic Analog Computers** (1952 and 1956) and **Mathematical Handbook for Scientists and Engineers** (in print). He is co-editor-in-chief of the forthcoming McGraw-Hill **Computer Handbook** and has published many technical papers on analog computers and automatic control.

This summer Dr. Korn is teaching a course and getting an analog computer started at the National University of Mexico.

Electrical Engineering Department at the University of Arizona teaches and uses modern electronic analog computing techniques in a number of graduate and undergraduate courses, as outlined in Table 1.

Undergraduate Program

The undergraduate analog-computer program comprises a lecture course (EE 272) and a laboratory course (EE 273). Here seniors learn how analog computers establish specific mathematical relationships between physical variables and thus make physical systems behave at least approximately in the manner of mathematical models. The students are taught standard modern simulation techniques used to solve many engineering problems in industry (Fig. 1). An important purpose of the course program is to introduce analog-computing elements as components of control and instrumentation systems.

Graduate Program

The graduate analog-computer course (EE 370) also introduces its subject with a brief review of simulation methods. This course is, however, essentially concerned with the design of up-to-date analog-computer components and systems; the objective is to establish desired mathematic relations between physical variables, particularly in control and instrumentation applications. Emphasis is given to the use of operational amplifiers in connection with special diode networks to implement accurate *nonlinear control* characteristics and automatic decisions.

In the graduate course on random processes and noise (EE 335), we attempt to develop a laboratory program that relates random-process theory to actual demonstrations involving physical random

Engineering Department

GRANINO A. KORN
Professor of Electrical Engineering
University of Arizona

processes. Analog simulation has been used to illustrate the effects of noise in control systems and detection, and to demonstrate the determination (estimation) of statistical parameters such as probabilities, correlation functions and spectra. The direct and adjoint-system methods of computing mean-square system errors are taught by simple analog demonstrations.

Although most of the engineering curriculum is

TABLE 1—ANALOG COMPUTER COURSES IN THE DEPARTMENT OF ELECTRICAL ENGINEERING

UNDERGRADUATE (SENIOR) COURSES

Open for graduate credit in electrical Engineering or in Systems Analysis; also Special-projects course—(EE 299)

EE 272: Analog Computation
(3 points)
Basic computing elements and simulation techniques

EE 273: Analog Computer Laboratory
(1 point)

Experiments:
1. Basic Computing elements; Slow and repetitive computers
2. Simple differential equations
3. Coupled oscillations, vibration absorber
4. Special diode circuits
5. Servomechanism simulation
6. Aircraft and autopilot simulation
7. Nonlinear oscillations
8. Division and square-root loops
9. Equipment maintenance checks

GRADUATE COURSES
(also special-projects and thesis courses)

EE 370: Electronic Analog Computers
(3 points)
(Prerequisite: basic servo course)
Review of simulation techniques; equipment design

EE 335: Random Processes and Noise
(3 points)
(Prerequisites: Mathematical statistics, integral transforms)
Basic random-process theory. Computers are used to demonstrate sample functions, ensemble and time averages, amplitude distribution; direct and adjoint-system simulation of linear time-varying systems.

Each course involves a term paper (35 percent of course credit), usually a simulation project or development project. Projects can be undertaken jointly by two students.

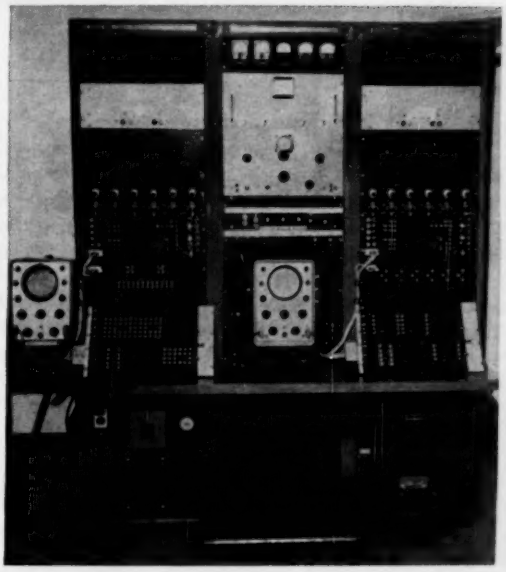


FIG. 1. A COMPUTER INSTALLATION specifically designed for the dual purposes of instruction and analog-computer development. The machine has only a small number of operational amplifiers and 4 electronic multipliers, but it comprises a modern push-button control system, digital readout, and individual control of integrators for automatic programming. The machine can be used either as a single computer or as a pair of smaller machines, and the instructor can connect various external equipment into the students' plug-in-patchboards by means of patching connections on special transfer patchbays. The machine is equipped for multi-shift operation with interchangeable plug-in patchboards.

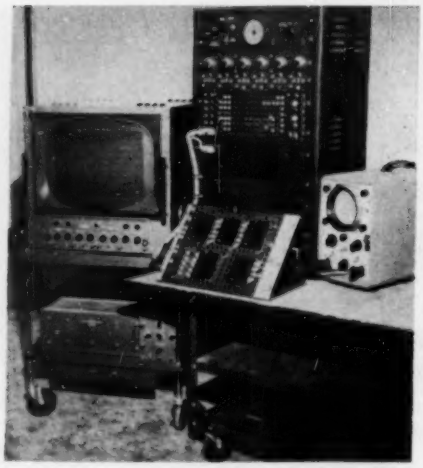


FIG. 2. A SMALL ANALOG COMPUTER mounted on a wheeled table serves for class demonstrations, with a large display oscilloscope. The machine can also be slaved to one of the larger computers to provide additional capacity. The patchboard was especially designed for use by students.

TABLE 2—ANALOG COMPUTER LABORATORY PROJECTS, 1959/60

1. New Accurate Limiters and Electronic Switches
2. Development of High-Speed Operational Amplifiers
3. System Design
   - Control Circuits
   - Patchbay Layout
   - Automatic Programming
4. Development of
   - Noise Generators
   - Miscellaneous
   - Theoretical Studies
   - Simulation Techniques
   - Limit stops
   - Sampled-Data Systems
   - Two-Mode and Adaptive Servos
   - Linear Programming
   - New Electronic Multipliers
   - Quadrant Switches for Resolvers
   - Analog Storage Circuit
   - Accurate Slicer
   - Sampling Circuits
   - Integrator Reset Circuits
   - Timers
   - Analog-to-Digital Converter
   - Decision Circuits
   - High-Speed Computation and Switching
5. Student and Research Computers
   - New Repetitive Analog Computer
   - Electronic Amplitude-Distribution Analyzers
   - Squarers, Correlators
   - Random-Process Studies
   - Through sampling of repetitive solutions (GPS-type Monte Carlo Technique)
   - Probability Density
   - Correlation Functions
   - Mean Square Delay Error

concerned with the teaching of principles, the analog-computer courses do attempt to teach a certain amount of *technique. At least 30% of the grade for each course is based on a term paper involving either a special simulation project or a short development project.* This is true for both graduate and undergraduate courses.

Once a student has been checked out on the analog computers he is encouraged to use these machines for special projects. The undergraduate will use a computer under supervision; the graduate student without supervision. The computers are available on a first-come first-serve basis.

The analog facility also is used intermittently for demonstrations in various courses in control systems, differential equations and nuclear engineering. The mechanical and nuclear engineering departments are now developing analog facilities of their own.

Facilities

At present, the Analog Computer Laboratory has five complete electronic analog computers used for teaching and research purposes; a sixth machine is in the design stage. Equipment includes smaller computers specifically designed for convenient instruction and demonstrations, repetitive analog computer, and a fairly large 50-amplifier machine which compares favorably with late equipment used in industry (Fig. 3). Except for the older repetitive analog computer all machines were designed and built in our laboratory with use of commercially available chopper-stabilized d-c amplifiers.

The larger machines have digital readout and provisions for automatic programming.

Development Work

Table 2 shows how our development projects fit together and complement one another. In the field of component development our main interest is in *accurate electronic switching techniques* intended to give the analog computer a measure of the decision making, automatic-programming ability of digital computers. Our fast switching techniques have been applied to the design of new electronic *multipliers* and *devices for measuring statistical parameters* as well as to new simulation techniques.

In an effort to permit faster switching, and especially in order to design more accurate repetitive computers we have developed new *fast operational amplifiers* capable of operating up to one-half-megacycle frequency in suitable applications. Our new *repetitive computer project* will use the fast all-parallel operation of the analog computer to permit computation of statistical parameters from large samples (1000 to 10,000) of computer solutions with random inputs or initial conditions.

Many development projects include undergraduate term papers and M.S. thesis projects. The laboratory's Ph.D. program in Electrical Engineering is concerned with the utilization of analog computers for statistical studies of control systems and communications. The first Ph.D. thesis project has been started on the subject of random-process studies with a repetitive analog-computer.

TABLE 3—PROGRESS OF A TYPICAL HALF-TIME GRADUATE ASSISTANT (M. S. CANDIDATE)

	Duties in Analog Computer Laboratory	Typical Course Work
Semester 1	Familiarization with equipment maintenance Build some equipment Teach one section of undergraduate analog computer laboratory	Integral transforms Mathematical statistics Digital Computers or Methods of Theoretical Physics
Semester 2	development project in support of Ph. D. thesis or faculty research supervise undergraduate technicians	Electronic Analog Computers Pulse and Digital circuits Random Processes and Noise Network Synthesis or Control-system synthesis
Summer	Supervise 2 Undergraduate technicians in construction Start M.S. Thesis work	
Semester 3	Supervise maintenance development project for M.S. Thesis	Sampled-data control systems Network synthesis or Communications/Detection Theory Thesis

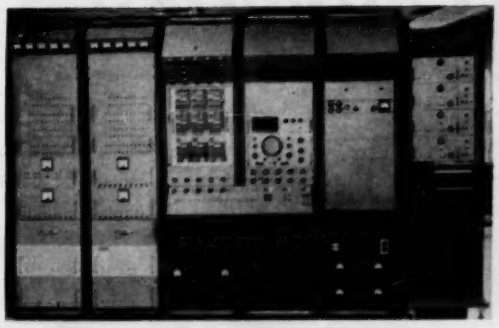


FIG. 3. UNIVERSITY OF ARIZONA'S "Bec!man Project," a 50-amplifier analog computer, combines Beckman-Berkeley amplifiers and Electronic Associates servos (donated by their manufacturers) with a new patchbay (provided by Tucson businessmen) and a student-designed push-button control systems. A second-year graduate student is the project supervisor.

Experience for Graduate Students

A serious attempt has been made to dovetail undergraduate instruction (student term papers) with more advanced development work (M.S. and Ph.D. thesis projects). Whenever possible, we arrange the work so that two or more undergraduate term papers support a graduate-assistant's Master's thesis project. In turn, these projects, together with term papers in our graduate courses, often constitute supporting experiments for our Ph.D. program. In this manner M. S. and Ph.D. candidates serve as project supervisors and can develop valuable experience in group supervision; incidentally, they relieve the teaching faculty of detailed supervision tasks.

Table 3 shows the *progress of a typical graduate assistant employed in the Analog Computer Laboratory.* In addition to a reasonable program of courses in mathematics, circuits, computation, control and random processes, the three-semester course affords the graduate student a substantial amount of practical industrial-type development work, including supervision of undergraduate technicians.

After familiarizing himself with the laboratory's equipment during his first semester, the second semester sees the graduate student in the process of teaching laboratories and supervising undergraduate development projects. During the following summer, one of the graduate assistants is in sole charge of the laboratory with its undergraduate technicians, usually engaged in the construction of new analog computing equipment to be used in the following school year's teaching or development program.

A complete electronic analog computer has been built from modified commercial components during such a summer session. The graduate student was in sole charge of this program; indeed, the professor in charge of the laboratory was away for the Summer. The graduate assistant wrote requisitions for parts, supervised the technicians, made on-the-spot design decisions, and tested the finished equipment. During the last semester of their M. S. program the graduate assistants may still teach one section of the analog computer course, but an effort is made to relieve them of all technicians' duties, maintenance work, etc., in order to permit them to devote themselves to their own Master's thesis. In this they, in turn, receive supporting data from undergraduate term papers set up for this purpose.

An effort has been made to encourage our graduate students to publish their findings (references 3 to 5) and to let our undergraduate students use their term papers in AIEE-IRE student-paper competitions.

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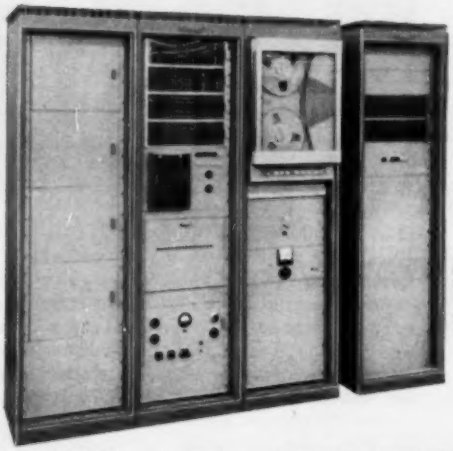
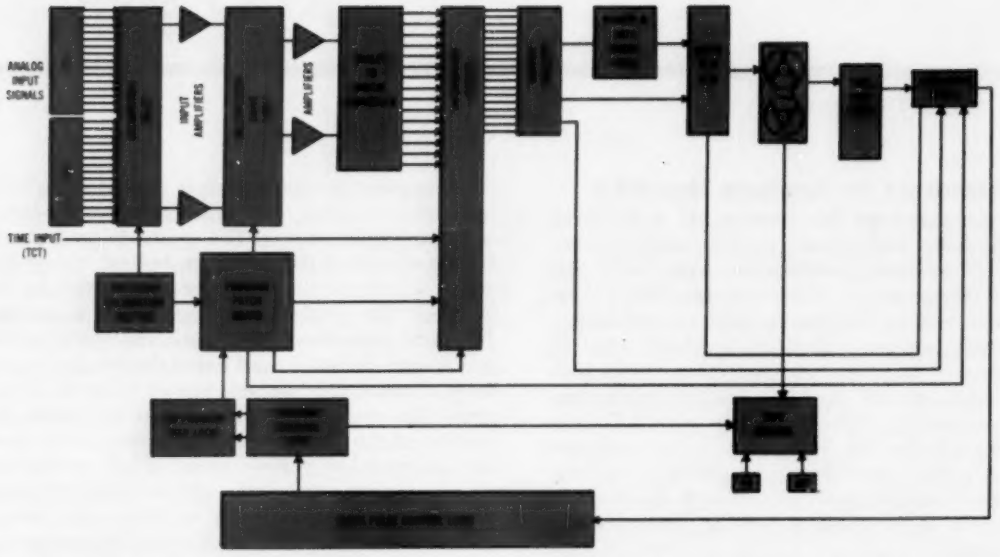
3. Korn, G. A., and T. M. Korn, *Electronic Analog Computers*, 2nd. Ed., McGraw-Hill, N. Y., 1956
4. Koerner, H. and G. A. Korn, Function Generation with Operational Amplifiers, *Electronics*, November 6, 1959
5. Caldwell, W. F., G. A. Korn, V. R. Latorre, and G. R. Peterson, A Precision Amplitude-distribution Analyzer, *Trans. IRE/PGEC* June, 1960 (in print)

Epsco-West NEWSLETTER



Meeting Tough Specs for Bell Labs



Epsco-West engineers met tough requirements for Bell Telephone Laboratories for a very accurate high speed data handling system.

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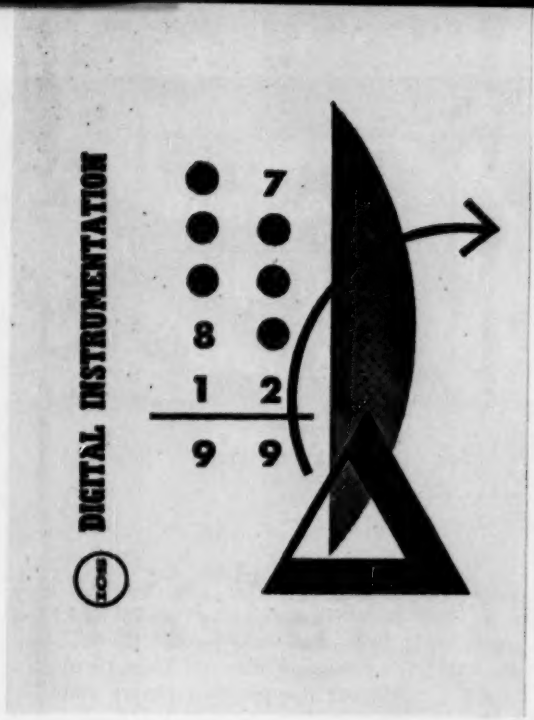


Serial conversion of Gray code to binary code can be implemented by a basic flip-flop package.

ROBERT BROOKS
Computer Control Co.

Gray-to-Binary Conversion

TABLE 1—DECIMAL, GRAY, BINARY EQUIVALENTS.

Decimal	Gray	Binary
0	0 0 0 0	0 0 0 0
1	0 0 0 1	0 0 0 1
2	0 0 1 1	0 0 1 0
3	0 0 1 0	0 0 1 1
4	0 1 1 0	0 1 0 0
5	0 1 1 1	0 1 0 1
6	0 1 0 1	0 1 1 0
7	0 1 0 0	0 1 1 1

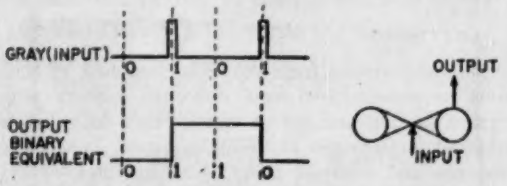


FIG. 1. CONVERSION of decimal number 6 from Gray code to binary.

AN IMPORTANT APPLICATION of a binary flip-flop is serial conversion of Gray code to binary. When the Gray code is the input to a flip-flop, its output is the binary equivalent.

The Gray code (used in shaft-to-digital converters) is a reflected code—that is, only one bit changes value every time the number is increased one unit. As the Gray number is not easily read by an operator, and is not easily manipulated arithmetically a conversion to binary code is employed frequently. The binary code and its equivalent Gray code are shown in Table 1.

An interesting relationship exists between a Gray code and a binary code—if you feed a Gray-code *pulse* signal to a flip-flop serially (high order first), then the output *state* of the flip-flop is the binary equivalent.

For example, referring to Fig. 1, if the Gray pulse signal 0101 is fed to the common input of a flip-flop (which switches state on every pulse), the output state of the flip-flop (one side) will be 0110. Referring to Table 1, it is seen that this is the binary equivalent of the Gray number. The Gray number must be read from left to right—that is, the highest-order bit must come first. The binary output state starts at 0 at the beginning of each reading.

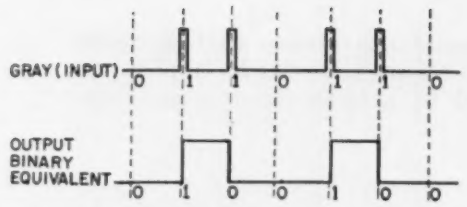


FIG. 2. CONVERSION of decimal number 38 from Gray code to binary.

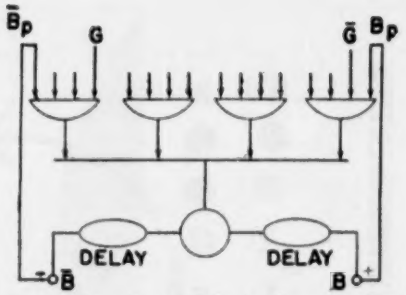


FIG. 3. AND gate at left implements $G \cdot \bar{B}_p$. Gate at right implements $\bar{G} \cdot B_p$. Buffer performs OR logic to produce output $B = G \cdot \bar{B}_p \vee \bar{G} \cdot B_p$.

Fig. 2 shows the Gray code number 0110110 (equivalent to decimal number 38) fed to a flip-flop. The output state is 0100100, which is the binary equivalent of 38.

The logic statement for a flip-flop output is:

$$A \cdot \bar{B} \upsilon \bar{A} \cdot B$$

(This is the familiar exclusive OR statement used previously for the sum signal in addition.)

The logic statement for a serial Gray-to-binary converter is of identical form:

$$B = G \cdot \bar{B}_p \upsilon \bar{G} \cdot B_p$$

where G is the pulse-type Gray signal of the column being read; B_p is the state of the binary bit of the previous (higher-order) column, and B is the binary state of the column desired. Thus there is a binary 1 whenever the previous binary state already was 0 and the Gray pulse is 1, OR whenever the previous binary state already was 1 and the Gray pulse is 0. Implementation requires feedback loops for B_p (Fig. 3).

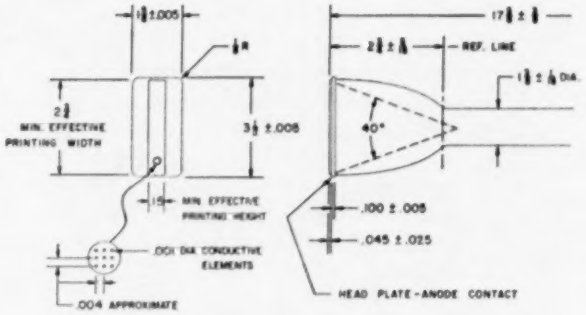
Addition to our previous survey of loggers and printers:

Electronic Printer

New Litton Printapix direct printing CRT's (Types L-4013 and L-4016) employ a metallic element mosaic target or printing head in place of the phosphor screen usually found in cathode-ray tubes.

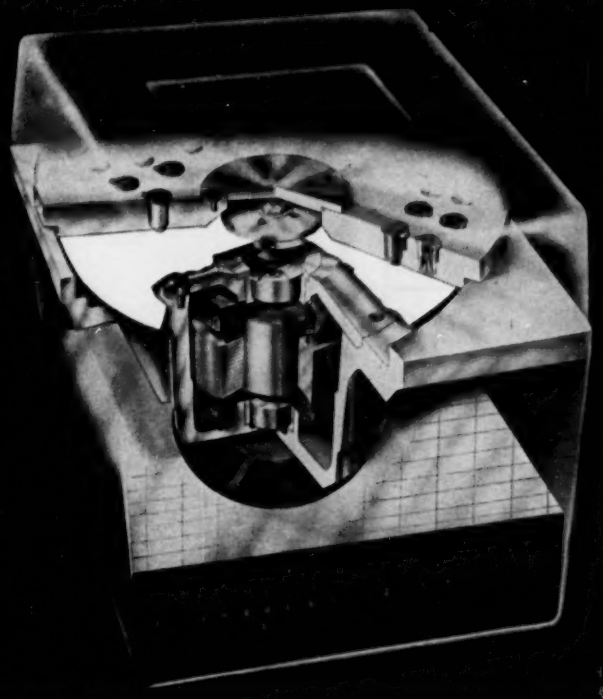
The Litton type L-4013 tube provides a printing or writing head 0.15" high to accommodate writing of complete characters or symbols across the entire head width of 2¾". This two dimensional head may also be used for sequential scan line (TV type) operation.

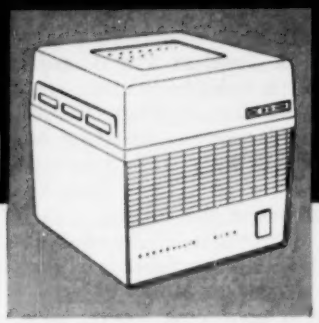
Electrons in a high intensity, high definition beam in the Printapix tube produce a charge pattern on a dielectric surface, such as ordinary paper or plastic, through a unique mosaic printing head. This mosaic head is an orderly array of 0.001"-diameter metallic elements penetrating a thin, vacuum-tight glass face plate. The charge image, either line or continuous tone, is rendered instantaneously visible by adherence of a pigmented power or floc, which may be permanently fixed be a rapid heat process, or erased for reuse of the base material.



Simplicity results from the direct coupling of electrons to nonsensitized base dielectric, without conversion to light and use of optics. High definition is achieved through use of 0.001" diameter conductive elements and electron beam. Writing rates of 0.1 usec per element are achieved. It uses an inexpensive and reusable base material and dry developer. It is made by Display Devices, Litton Industries, Electron Tube Division, 960 Industrial Rd., San Carlos, Calif.

simplest rotating storage device ever developed...





The Bernoulli Magnetic Disk Memory, a proprietary development of The LFE Applied Research Laboratory, is now available in prototype or production quantities.

The first models, designated as the BD-100 Series, are ideally applicable for use in general purpose EDP Systems. In addition, because of each unit's small size and weight, and ability to withstand severe environmental conditions, the BD-100 Series is also applicable to a wide variety of fixed station and mobile digital computers. For a complete description write for Technical Data Digest No. 607I.

SPECIFICATIONS BD-100 SERIES

Storage Capacity (Max) Bits	100,000
Bits Per Track (Max)	3,000
Bit Rate — kc	90-400
Track Layout As Required Typical:	
Total Tracks	40
Data Storage Tracks	32
Spare Tracks	3
Clock and Timing Tracks	3
Register Tracks	2
Number of Registers	4
Register Length — Bits	32
Register Adjustment — Bits	±3
Disk Speed — RPM Induction or Synchronous Motors Available	1800-8000
Power Source — cps	60-400
Magnetic Heads (Compatible with solid state circuits) Typical: (For 200 kc Operation)	
Inductance (Per Leg. — C.T. Coil) — uh	55
Write Current (P/P Manchester) — ma	250
Read Out (Min. P/P Full Coil) — mv	20
Size — Inches (Less Electronics)	9 x 9 x 5
Wide variations from typical specifications can be made to meet customer's requirements.	

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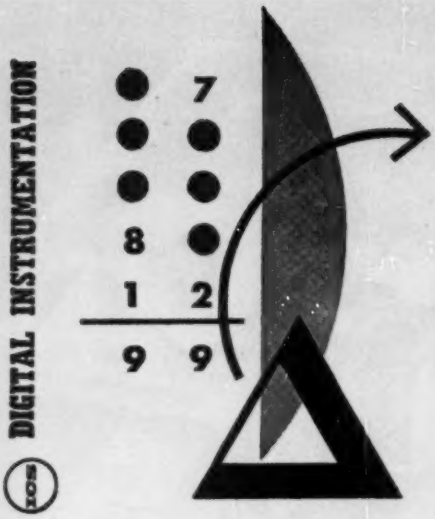

Decade Counting

Here are ten different ways flip-flops can be connected to make a decade counter.

ED BUKSTEIN

Northwestern TV and Electronics Institute

Notes on Terminology

The flip-flop symbol used in this article is nonstandard, although it is used by a commercial firm. A standard symbol is needed, and this one is suggested. There is the matter of distinguishing between binary and flip-flop. Most people in the field are inclined to disregard the distinction and to use the terms binary and flip-flop interchangably. The symbol can qualify for both.

To complicate matters further, the output of a flip-flop may be taken from either the conducting or the nonconducting side, depending on whether a negative- or positive-going signal is desired. Further complications occur in transistor circuitry because supply voltage may be either negative or positive.

One technique for resolving this problem in semantics is to employ the terms **one-input, one-output, zero-input** and **zero-output.**

ZERO-INPUT TERMINAL: the terminal which (when triggered) will put the flip-flop in the zero (starting) condition. If flip-flop is already in zero condition, the input to the zero-input terminal will not alter the state. Also called RESET terminal by some manufacturers.

ONE-INPUT TERMINAL: the terminal which (when triggered) will put the flip-flop in the one (opposite of starting) condition. Called the SET terminal by some manufacturers.

ZERO-OUTPUT TERMINAL: the terminal which produces output (of correct polarity to trigger a following circuit) when the flip-flop is in the zero condition.

ONE-OUTPUT TERMINAL: the terminal which produces output (of correct polarity to trigger a following circuit) when the flip-flop is in the one condition.

BINARY COUNTERS offer the advantage of maximum counting capacity with minimum components, but readout requirements often dictate the use of decade counters. The decade counting circuit is usually derived from a four-stage binary counter (such as four flip-flops), which has a normal counting capacity of 16 (stage one counts by 2, stage 2 counts by 4, stage 3 by 8, and stage 4 by 16).

In order to convert the counter capacity of 16 to a capacity of 10 it is necessary to skip six steps. This can be done in many ways, such as skipping the last six counts (resetting to zero after 10 counts), skipping from count 8 to the state existing at count 14, etc.

Fig. 1 shows the circuit of a flip-flop. This circuit can have one of two states only: if one half of the tube is conducting, the other half is nonconducting. If the left half of the tube is conducting, the right half of the tube is nonconducting. When

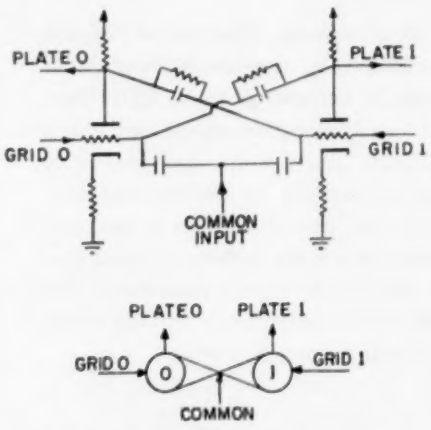

FIG. 1. FLIP-FLOP circuit (above) and symbol (below). Note that common driving signal to both grids is brought into the intersection of the diagonal. Lines on ends of symbol connect to a grid directly.

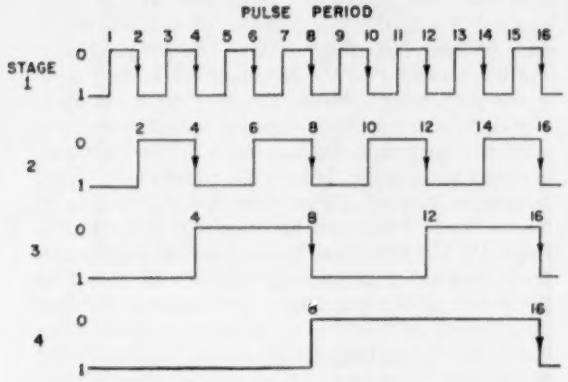

FIG. 2. STATES of the 1 sides of a four-stage counter. Each negative-going pulse from a stage triggers next stage.

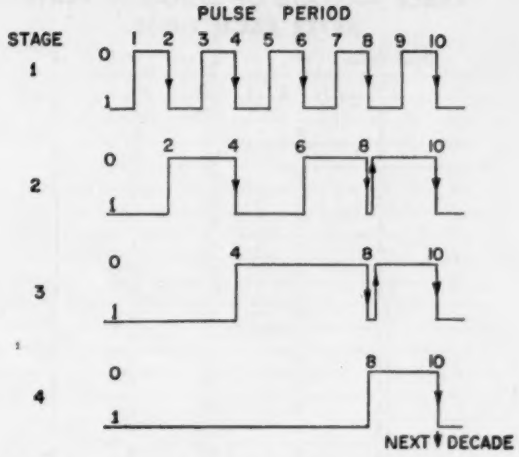

FIG. 3. STATES of the 1 sides of the decade counter shown in Fig. 4,B.

one half of a flip-flop is conducting (and its output voltage is low), it is said to be in the 1 state. When that half is nonconducting and its output is high, it is in the 0 state. If one half of a flip flop is in the 1 state, the other half is in the 0 state, and *vice versa*.

If a succession of *negative pulses* is applied to the input, the pulses will reach both grids via the 10-uuf coupling capacitors. However, only the conducting half of the twin triode is able to respond to these negative signals because the nonconducting half cannot react to a negative signal on the grid. The circuit will respond to each negative input pulse by reversal of left and right conducting states. This results in a negative fall of output 1 (or output 0) once for every two negative input pulses to the input. As there is one negative-pulse output for every two negative-pulse inputs, the circuit can be said to be counting by two's, or dividing by two.

Table 1 shows the state (conditions of one flip-flop plate) for each of the 16 counts in a 4-stage flip-flop counter. The table shows the state of only one side of each flip-flop stage. (It is not necessary to show the state of the other side of the flip flop because its state is always the reverse of its companion.) The two sides of the flip flop can be called the 0 side and the 1 side. The 0 side simply means the side that is nonconducting when the count is zero.

The incoming negative pulse train changes the state of the first flip-flop every pulse (Fig. 2). The output of the 1 side of the first flip-flop stage is used to fire stage two. Thus stage two changes state only when the 1 side becomes conductive, thus producing a negative pulse. Each succeeding stage changes state only when the 1 side of the stage preceding goes from 0 to 1 (nonconducting to conducting).

Fig. 4, A shows the basic 4-stage counter with a capacity of 16 counts. That is, stage 4 produces a negative-going output pulse once for every sixteen input clock pulses. This is shown in Fig. 2.

A neon lamp connected across the plate load of the zero side of each stage would be lighted when it is in the 1 state (conducting). The lamps can be assigned weighted values that are added, if the lamp is lit, to reveal the pulse count. The weight for each lamp at each stage in Fig. 4,A is 1, 2, 4, 8, respectively. Lamps can be across the plate load of the zero side, or they can be connected between plate and ground on the 1 side.

Decade Counters

In order to convert the counter capacity of 16 to a capacity of 10 it is necessary to skip six steps. This can be done in many ways, such as skipping the last six counts (resetting to zero after 10 counts), skipping from count 8 to the state existing at count 14, etc. Techniques include feedback networks, feed-forward circuits, logic and gating circuits, forced resetting, or presetting.

Fig. 3 shows the pulse sequence for a decade counter connected as shown in the block diagram of Fig. 4,B. When the fourth stage changes state at the count of 8, its 0 side goes from 0 to 1, as shown in Table 1. This negative-going pulse is brought back to the second and third stages and used to cut off their conducting side, reversing their state.

After this feedback pulse has arrived, the 0 sides of the four stages shown are 0, 1, 1, 1, respectively. Note from Table 1 that this is identical to the states existing after the 14th pulse. The counter now has received eight pulses and yet is only two pulses shy of reaching its capacity. The next two pulses reset the counter to its initial zero condition, and the fourth stage provides the negative-going output pulse to trigger the next decade.

The arrangement shown at B of Fig. 4 is known as a 1242 decade; four neon lamps connected to the four stages would be assigned values or "weights" of 1, 2, 4, and 2, respectively. In other words, at

TABLE 1—STATE OF ZERO-SIDE PLATE AFTER EACH PULSE.

Pulse	Stage 1	2	3	4
0	0	0	0	0
1	1	0	0	0
2	0	1	0	0
3	1	1	0	0
4	0	0	1	0
5	1	0	1	0
6	0	1	1	0
7	1	1	1	0
8	0	0	0	1
9	1	0	0	1
10	0	1	0	1
11	1	1	0	1
12	0	0	1	1
13	1	0	1	1
14	0	1	1	1
15	1	1	1	1
16	0	0	0	0

the count of 6, lamps two and three would be lit.

There are many other ways in which a pulse from one stage can be used to reset the other stages to a desired condition. Refer to Table 1 whenever necessary to follow the operations to be described.

Two feedback networks are used in the arrangement shown at C of Fig. 4. When the 0 side of the third stage goes to 1 (4th pulse), a feedback pulse cuts off the 1 side of the second stage. Referring to table 1, the states at stage 4 were 0010; the feedback changes this to 0110, which is equivalent to state 6. This simulates the effect of 2 additional input pulses. When the 0 side of the fourth stage goes to 1 (6th pulse), it re-triggers the third stage, simulating the effect of an additional 4 input pulses. Referring to table 1, at eighth pulse (now actually the 6th pulse), the states are 0001; the feedback changes this to 0011, which is equivalent to count 12. Hence there are only 4 more counts to the final count.

Six pulses have now been skipped and the total count again is reduced from 16 to 10. Front-panel indication of the pulse count can be obtained by means of four neon lamps representing 1, 2, 2, and 4, respectively. In this type of decade counter the two feedback loops are independent; the fourth stage will trigger the third stage, but not the second.

The arrangement shown at D in Fig. 4 resembles B. Pulse count in this circuit can be indicated by four neon lamps representing 1, 2, 1, and 5 respectively. When the third stage of this circuit turns on (4th input pulse), feedback turns on the first and second stages also. This action simulates 3 input pulses and occurs twice during a complete counting cycle of 10 input pulses. This again reduces the normal count of 16 to a count of 10.

The 1125 decade shown at E resembles C. The first three stages of the circuit can be considered as a scale-of-five counter; feedback simulates 3 input pulses and therefore reduces the normal count for three stages from 8 to 5. The final binary stage doubles this ratio, producing an over-all count of 10. As in the 1224 decade (C), each feedback loop can trigger the preceding stage only.

The 1248 decade shown at F employs feed forward from the first stage to the last stage. Each time the 1 side of the first stage goes to 1 it feeds forward a negative-going pulse to cut off the 0 side of the last stage. This feed-forward circuit has no effect on the last stage while the 0 side is nonconducting (during the first eight counts). The eighth count feeds forward a negative-going pulse that arrives at the last stage before its 0 side becomes conducting, before the count-eight signal progresses through stages two and three; thus it has no effect. Pulse nine has no effect on the fourth stage. On the 10th input pulse, the first stage again feeds forward a negative-going turn-off signal to the 0 side of the last stage. The 0 side of the last stage resets to 0 and a negative-going pulse from the 1 side is fed back to the second stage to reset the second stage to 0. All stages are now in their zero condition—after 10 input pulses.

In the arrangement shown at G the circuit is preset to a count of 6. Each time the 1 side of the fourth stage goes to 1 (pulse count completed), the negative-going signal is fed back to cut off the conducting (1) side of the two preceding stages. Thus the circuit begins each counting cycle with a simulated count of 6; the total capacity again is reduced from 16 to 10.

In the arrangement shown at H, the 0 state of the fourth stage is used to clamp the second stage in the zero state. The second stage cannot go to 1 as long as the fourth stage is at 0. When the 2nd input count pulse arrives, the first stage supplies a negative-going output pulse to both the second and fourth stages. The second stage cannot go to 1 because it is clamped in the 0 state. The fourth stage reverses. The four stages now are in the 0, 0, 0, 1 states, respectively, simulating the effect of 8 input pulses (see Table 1). Since eight input pulses are simulated when only two have been received, the net result is to reduce the total count from 16 to 10. After the 2nd input pulse the fourth stage is at 1 and the clamp is therefore removed from the second stage. For the remainder of the counting cycle, the count progresses in normal binary fashion and all stages are at 0 after 10 input pulses.

The arrangement shown at I consists of a three-stage binary counter (eight-count capacity) with an AND gate between the first stage and the second. The AND gate produces an output when both inputs are 1. This gate is used to block one pulse from going from the first stage to the second stage, canceling the effect of two of the input pulses. This requires two additional input pulses to compensate, and raises the total count capacity from 8 to 10.

The gate remains open until the 4th input is applied. At this time the third stage goes to 1 and feeds a negative-going trigger pulse to the gate-control flip flop, making its 1 side go to 0, closing the gate. When the 6th input is applied, the output of the first stage cannot reach the second, simulating the subtraction of 2 input pulses. The

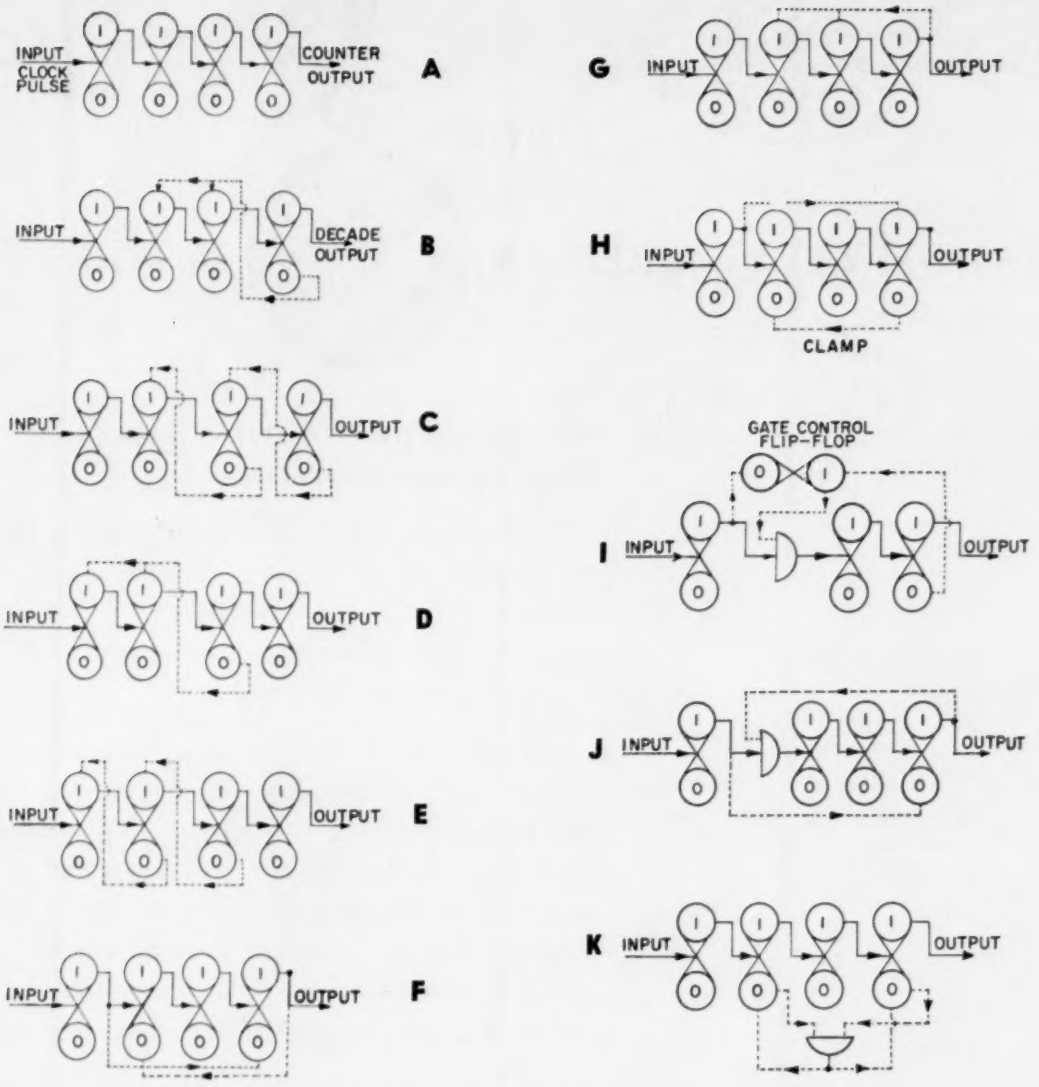

FIG. 4. FLIP-FLOPS hooked up as decade counters (except A which has a 16-count capacity) provide a negative-going output pulse from the fourth stage every tenth input pulse.

output of the first stage does, however, reset the gate-control flip-flop. The 1 side returns to 1 and re-opens the gate. Counting progresses normally for the remainder of the counting cycle.

In the arrangement shown at J, the first stage is coupled to the second through an AND gate that produces an output when its inputs are 1. One of the inputs to this gate is obtained from the 1-side output terminal of the last stage. The first stage is therefore coupled to the second only as long as the last stage remains untriggered (until after the 8th input). Counting progresses in the usual binary fashion for the first 9 input pulses. When the 10th input is applied, the first stage produces an output pulse that cannot pass through the AND gate because the last stage is reversed. The second stage therefore remains at 0. The output of the first stage also is fed forward to return the fourth stage to 0. All stages are therefore at 0 after the 10th input pulse.

The decade counter shown at K employs a ten-sensing technique. The AND gate is connected to the 0 side of the second and fourth stages. It produces an output when its inputs are both 1.

Counting progresses normally until the 10th input has been applied. At this time the 0 side of the second and fourth stages are both at 1. The AND gate produces an output that is used to reset the counter to zero by returning the second and fourth stages to 0.

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CHANGE VALVE TRIM IN 15 MINUTES

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Here's a control valve designed in steel and alloy steels that offers new assurance the valve you initially specify and install *will always fit an application*—even if changes in plans or future system changes might ordinarily call for complete valve replacement.

The new Leslie cage trim valve allows complete trim inspection in 15 minutes without removing the valve from the line. You can also switch valve action or size of actuator. Or, change valve characteristic or trim materials at will with an inexpensive interchangeable trim kit that reduces spare valve and valve parts inventories. Cage trim cuts maintenance and system modification costs to the bone—it's the kind of valve that makes foresight almost as good as "hindsight".

For sizing and capacity data on cage trim control valves, write for Bulletin or contact your Leslie Engineer—he's listed under 'Valves' or 'Regulators' in the Yellow Pages.

LESLIE **Leslie Co., 704B Grant Ave., Lyndhurst, New Jersey**

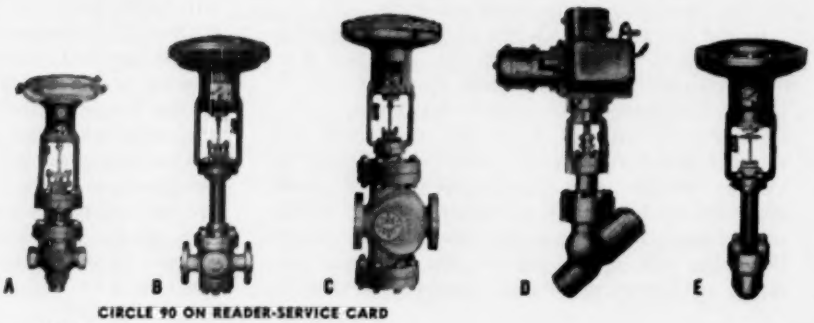
A Unbalanced valves up to 2500 lb ASA ratings.

B Piston balanced valves up to 600 lb ASA ratings.

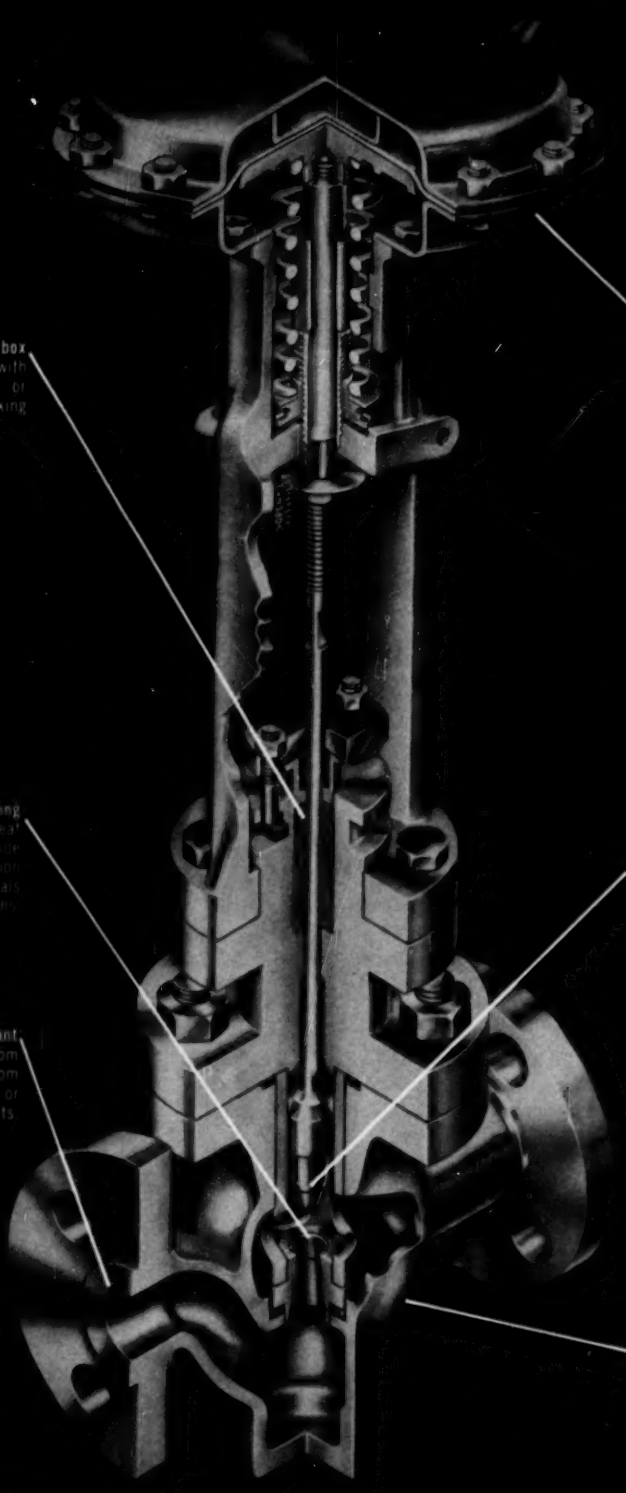
C Double seated control valves to 600 lb ASA ratings.

D High pressure-high temperature control valves.

E Angle body control valves.



CIRCLE 90 ON READER-SERVICE CARD



Flanged, thru-bolted stuffing box no lubricator needed with Leslie-Lubrisoft™ or Teflon V-Ring packing

Actuators for normally open or normally closed valves with 35, 55, 85 and 135 square inch effective areas

Long Life, Stellite seating surface on renewable seat insert for severe service. Wide variety of hard-surface corrosion and erosion resistant materials for other applications

Interchangeable inner valve shapes and materials: choice of needle plugs, V-port, quick opening, micro tapers

Corrosion erosion resistant materials in ASA rating from 150 to 2500 lbs. Select from a wide line to meet present or future system requirements

High Capacity Body any end connections in ½" to 3" sizes

TRADE LESLIE MARK

REGULATORS and CONTROLLERS

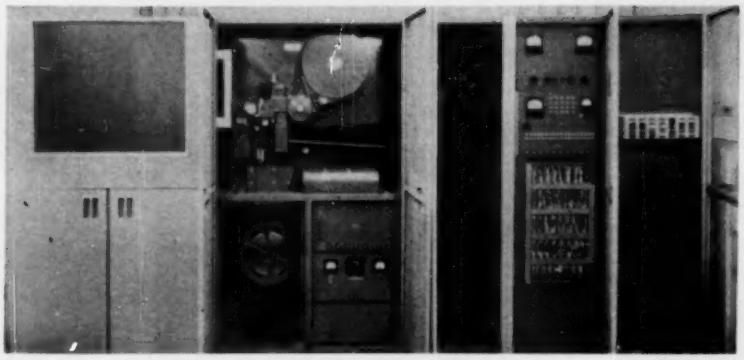


FIG. 1. High-speed printer.

Plotting 12,000 PTS/SEC

The Stromberg-Carlson S-C 4000 systems operate as peripheral equipment for the output of large-scale digital computers. Output is on 35-mm film in the form of plotted curves, tabular data or alphanumeric printing.

The S-C 4020 printer (Fig. 1) is compatible with most high-speed computers and data processing systems. Capabilities include: (1) Recording data on microfilm at 15,000 characters per second; (2) plotting graphs on microfilm at 12,000 points per second; (3) projecting selected data on direct-view screen less than ten seconds after film exposure. The heart of the system is the Charactron shaped-beam tube (Fig. 2).

Applications include plotting graphs, drawing axes, projecting grid backgrounds and printing vectors (Fig. 3). Full-page tabular copy can be printed. The form projector (optional) eliminates the need for preprinted forms, allowing both data and form to be photographed simultaneously. Mathematical formulae used for design of mechanical components and structures can be read in the form of drawings, with significant dimensions superimposed on the design. Ship's hull equations, aircraft wing sections, and other critical design components requiring descriptive geometry can be displayed graphically. Test and experimental computer programs can be monitored by the S-C 4020 during the course of the computation, providing an opportunity for manual intervention at any time.

Options available with S-C 400 printers include:

1. An *axis generator* that draws horizontal and vertical graph axes starting at any specific point in the display area.
2. A *vector generator* that draws straight lines between two given points, regardless of angle.
3. A *tape input unit* for use when off-line operation is desired.
4. A *form projector* that superimposes business forms on recorded data, eliminating necessity for pre-printed forms and making use of all computer time for processing variable information.
5. A *typwriter simulator* that provides typewriter-like spacing of printed tabular data and solid copy.
6. An *auto camera-projector* that processes film automatically. The information is presented on a console screen for visual interpretation less than ten seconds after the film is exposed.

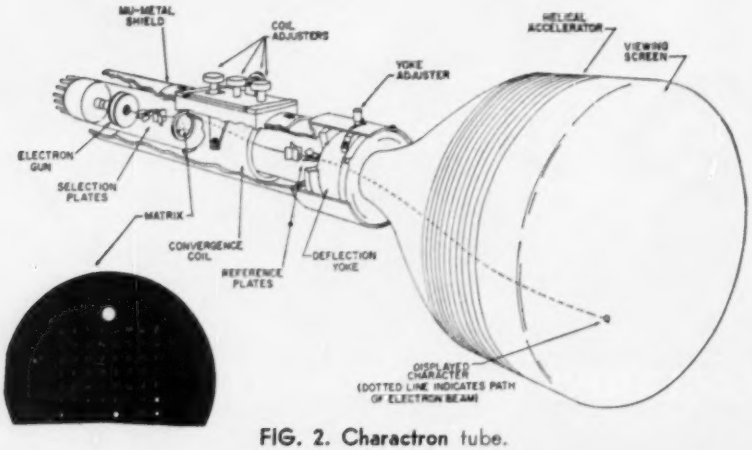


FIG. 2. Charactron tube.

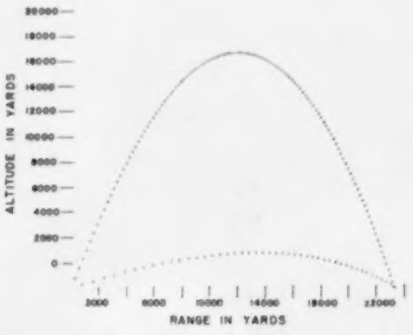


FIG. 3. PLOT OF MK 25 surface trajectories. Top curve is for 70° angle of fire; bottom curve is for 20° angle of fire.

CIRCLE 84 ON READER-SERVICE CARD ——→

Series N **PYROTROLLER®**—temperature indicating and controlling pyrometer.
PYROTAC®—continuous temperature indication with alarm signal and shut off.

You are now looking at the ***NEW***

Alnor®

PYROTROLLER® and PYROTAC®

(actual size)

All new—modern styling of case, designed for panel mounting and improved internal construction. But with the same time-tested Alnor movement. See next page for performance details.

Alnor®

Pyrotroller®—an electronic temperature controlling instrument that automatically controls the heat source to *maintain* a constant temperature within a set range.

Designed for temperature control on heat treating furnaces, ovens, heat sealing equipment, plastic moulding machines, cooking vessels, or any application where a precise uniform temperature must be maintained.

The Pyrotroller is a compact instrument occupying very little panel board space. The simple rugged circuitry has a minimum of components that operate well below their rated capacities. There is no shifting of the control point—no need for preselection of the one standard vacuum tube, no need for any adjustments at all on the electronic chassis.

Pyrotac®—a protective safety instrument that sounds an alarm, lights a signal light, shuts off heater circuits or fuel supply or any combination of these operations. Pyrotac protection can be added to present control systems to obtain a positive safety shut-off independent of other controls. It can also serve as the only control instrument on a process requiring complete shut down upon reaching a final preset temperature, or to notify the operator of the completion of a temperature cycle.

The Pyrotac can also be supplied for low temperature cut-out and many special applications, engineered to meet individual requirements.

The movement of these instruments is of rugged construction and includes the Alnico V magnet, hardened pivots, sapphire bearings, phosphor bronze springs and double pivoted moving coil. Both the Pyrotroller and Pyrotac have a water-proof and dust-proof case (die-cast aluminum) that protects the movement. Both can be supplied in explosion proof models.

(Attach this to your letterhead and mail)

Please send engineering information on the

☐ **PYROTROLLER®**

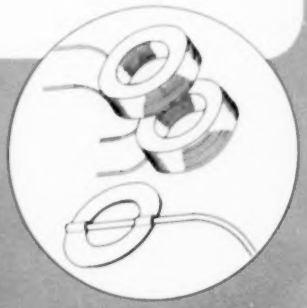
☐ **PYROTAC®**

NAME_____

COMPANY_____

ADDRESS_____

CITY_____ STATE_____



The Alnor Flux Gate Sensing Coils

When the loop passes between the two high frequency oscillator coils it alters their coupling thus actuating the relay.

ALNOR INSTRUMENT CO.
DIVISION OF
ILLINOIS TESTING LABORATORIES, INC.
422 N. LaSalle St., Chicago 10, Illinois

DESIGNED FOR RELIABILITY THROUGH
DAYSTROM-WESTON "UNITIZED" CONSTRUCTION

DAYSTROM-WESTON RECORDER HANDLES 2 TO 24 POINTS—WITH EASY INTERCHANGEABILITY

Proven in service by industry, the Model 6702 multi-point recorder accommodates up to 24 points in a single, compact unit. Number of points can be changed quickly. Accuracy is within ±0.25% of span or ±.025 mv on potentiometer.

Model 6702 features simplicity of design and performance. It has replaceable range standards and a plug-in amplifier. Printing and chart speeds are easily changed. Other advantages include the Weston D-PAK (T.M.) which eliminates standard cells, batteries and standardizing mechanisms . . . and a unique printed circuit switch is geared directly to the printing head.

Model 6702 is 39% smaller than the average multi-point recorder, and offers the convenience of rack mounting. It is designed and manufactured with traditional Weston craftsmanship to provide years of dependable, trouble-free service.

Ask your local Weston representative for complete information on this and other Weston instruments for industry, or write for Catalog 08-101-A. Weston Instruments Division, Daystrom, Inc., Newark 12, New Jersey.
In Canada: Daystrom Ltd., 840 Caledonia Rd., Toronto 19, Ontario. Export: Daystrom's International Sales Division, 100 Empire Street, Newark 12, New Jersey.

DAYSTROM, INCORPORATED
WESTON INSTRUMENTS DIVISION

CIRCLE 89 ON READER-SERVICE CARD

←——CIRCLE 84 ON READER-SERVICE CARD

An ICS ★ ★ ★ Staff Report

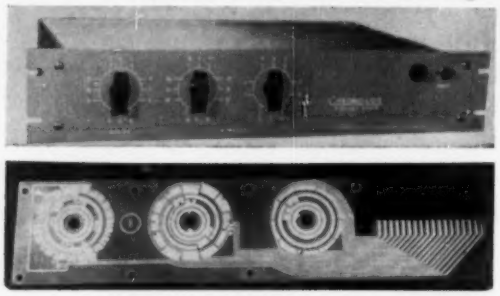


FIG. 1. **CHRONO-LOG** digital clock uses etched commutator and provides electrical contact closure output.

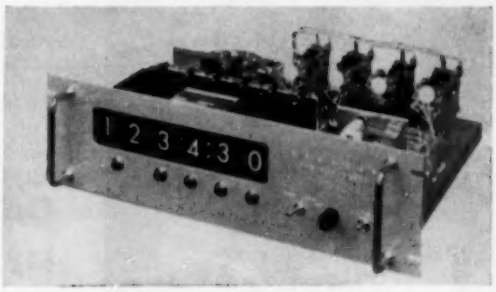
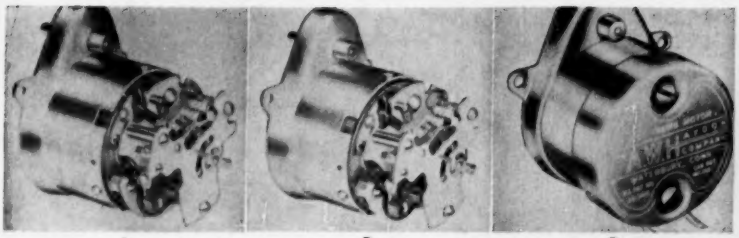


FIG. 2. **PARABAM** digital clock.

TIMERS

TABLE 1—COMPARATIVE TIMING TECHNIQUES

Type	Basic Uses (Intervals)	Accuracy	Advantage	Limitation
Synchronous Motor	Intervals greater than 15 seconds;	Same as that of source frequency	Long-time high accuracy	Time to reach speed
Synchronous Motor with Clutch	From 10 milliseconds	do	do	Unequal time for engaging and disengaging clutch
Induction Motor	Intervals greater than 1 minute		High torque	Speed depends on load & frequency
D-C Motor Reed Controlled	do	0.1-0.5%	Accuracy; high torque	Larger size
D-C Motor with Escapement Governor	do	to 0.1%	High torque; low time constant	Speed depends on voltage, load and temperature
Spring-Actuated with Escapement	Fraction of second to month	0.1%	Low cost; expendable	Low torque
Air Driven Escapement	do	do	No sparking hazard	Requires air source; accuracy
Crystal Oscillator	Long and short intervals (microseconds to months)	5 parts in 10^9	High accuracy	High cost
Tuning-Fork Drive	Milliseconds, and continuous source	1 part in 10^5	Accuracy	Cost; sensitivity to shock, vibration
R-C Networks	Milliseconds to minutes	1% to 5%	Solid-state type is rugged, low power drain, short reset time	Accuracy depends on constancy of charging voltage, and components
RELAYS				
Thermal Delay	<1 second to minutes	5%-10%	Simple, rugged, inexpensive	Accuracy depends on energizing voltage, cooling period
Dashpot	do	do	Easily adjusted	
Copper Slug	app. 1 second	do		
Pneumatic Oscillator	1 to 200 sec	<1%	No sparking; can use gas in remote installations	Requires clean air or gas source at 20 psig or higher



A B C

FIG. 3. A. W. HAYDON CO. timing motors.

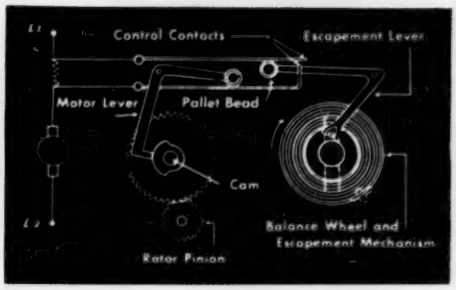


FIG. 4. BALANCE wheel and escapement govern d-c timing motor.

TIME is one of the most important quantities in all operations.

Available timing devices can (1) delay making or breaking a switch, (2) show time elapsed during an operation, (3) show in-use time totals for machines, (4) turn machines on and off at regular and irregular intervals, (5) operate a machine or process for a pre-set time duration, (6) vary set point with time, (7) program timed sequencing of single and multiple circuits, (8) track and control ballistic objects, etc. Comparative techniques are shown in Table 1.

Motor-Driven Timers

Digital representation of time is becoming increasingly important in loggers, computers, program control, and other applications. The output of a digital clock is a non-ambiguous parallel contact closure pattern representing time (decimal or binary-coded decimal). Not only the time of day (24-hr or 12-hr A.M. and P.M.), but the day and year can be represented digitally. Fig. 1 shows a digital clock (Model 2500 Chrono-Log). The rhodium plated, etched commutator is used in the digital circuitry. A digital calendar (Model 2800 Chrono-Log) provides a parallel decimal representation of months and days. Applications have been in industry (data loggers), science (in magnetometers), and computing (real time references).

Model 9000 digital timers, with three-digit and four-digit displays and electrical outputs, are available. Resolution can be from 0.001 to 0.1 hour. For example, a time resolution of 0.01 hour would provide a timing range of 00.00 to 99.99 hours.

Parabam Digital Clocks furnish non-ambiguous contact closures every minute, every tenth-minute or every second (Fig. 2). By providing up to 86,400 unique contact combinations per day these digital clocks are suited for time programming operations. Besides providing time-of-day contact closure output, the standard clock includes a single-plane, in-line lampbank display with pushbutton reset switches. Time measurement is derived from cam-operated switches driven by a 60-cycle synchronous motor. The pulses from the timers are used to operate a telephone-type step-switch counter. Clocks operating as count-down or elapsed-time indicators can be provided with minor modification.

Timing *motors* are available in many types (Fig. 3). A. shows a chronometrically governed d-c motor, using an escapement mechanism (A. W. Haydon Co.) to obtain an accuracy of 0.1% for line-voltage variation of 20% and 100% load variation. B. shows the Haydon 5700 Series governed d-c motor with cover removed to show the 300-beat governor that corrects motor speed 300 times per minute (5 times per second); escapement rate is from 0.1% to 0.5%, depending on voltage, ambient temperature and vibration. C. shows the Haydon basic d-c timing motor, a wound-rotor permanent-magnet type, with speed regulation on the order of 10%. A reversible 60-cycle a-c synchronous motor (26100 Series) also is available, as are 25, 50 and 400 cycle models.

Fig. 4 shows the principle of the chronometrically-governed d-c timing motor.

Amglo Corporation's reed-controlled, d-c timer (Fig. 5) can deliver 900 rpm to 1 revolution per day. Accuracy ranges from 0.1% to 0.5% under variable voltage and load operating conditions. Sufficient torque is provided to operate up to 30 cam and switch arrangements.

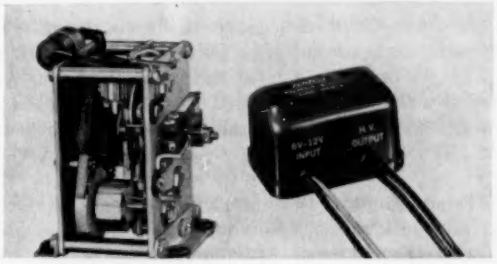


FIG. 5. AMGLO CORP. d-c timer motor.

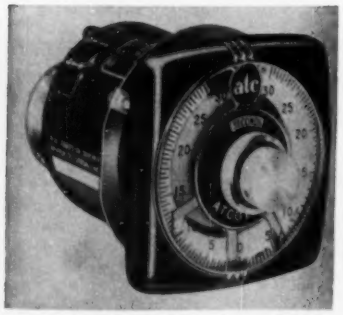


FIG. 6. ATC Model 306 timer has dual circuit for control of two independently set functions.

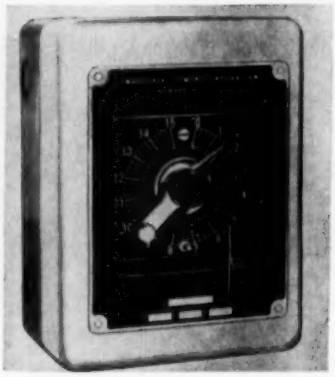


FIG. 8. INDUSTRIAL Timer Corp., Series PAB timer.

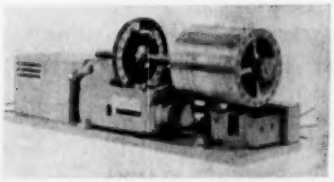


FIG. 10. PROGRAMONITOR uses pegs projecting from drum to operate switches.

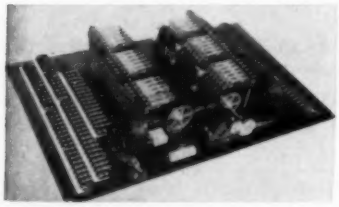


FIG. 7. ATC Model 2400 timer has cams for programming many functions.

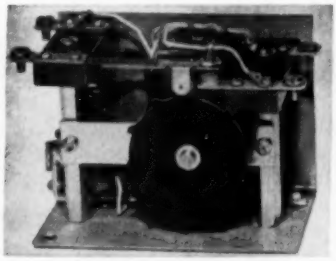


FIG. 9. SIGNATROL cycle timer showing cam for on-off pattern.

FIG. 11. ZENITH time switch provides multiples of 15-minute duration.

Fig. 6 shows a dual-circuit, dial-set, miniature, synchronous-motor-driven timer for control of two independently set functions, offered by Automatic Timing and Controls.

A timer-programmer using synchronous-motor-driven cams and featuring stop cycle, repeat cycle control, and programming with flexibility of speed adjustment and circuitry, is shown in Fig. 7 (ATC Model 2400 Timer).

The series PAB instantaneous reset timers of Industrial Timer Corp. (Fig. 8) is specifically designed for process control in industrial applications. Unit has automatic instantaneous reset, time setting adjustment, large numerals on large, easily read dial. Simple clutching mechanism provides a wide timing range. Industrial Timer also offers manual set timers, automatic reset and signaling timers, running time meters, time totalizers, etc.

A cycle timer can make or break circuits on prearranged time settings. The Signatrol cycle timer (Fig. 9) provides a total time period of 150 seconds, which can be divided into any sequence of on-off combinations. Contact rating is 15 amperes at 115 v ac.

Programonitors (Counter and Control Corp.) are offered in a variety of models that can be classified in three basic forms—(1) shaft driven, for counting revolutions, (2) lever operated, to pick up count from reciprocating motion, and (3) solenoid operated, to count electric impulses.

Programonitors (Fig. 10) can provide cycles as high as 4000 counts. Adjustment of cycle settings is in 1-count increments up to 2000 counts and in 2-count increments from 2000 to 4000 counts. Models for shorter ranges also are produced. The operator also can introduce any number of intermediate switching points, regular or irregular, within the predetermined cycle. The pattern can be recycled indefinitely.

As many as 48 on and 48 off commands can be set with the time switch (Zenith Electric Co.) shown in Fig. 11. Dial-mounted tabs provide multiples of 15-minute time duration.

Timed switches, program clocks, cycle timers, interval timers, and time-delay relays are available from Lumenite Electronic Co.

MLPR-13 Programmer (Beattie-Coleman, Inc.) uses 160′ of punched Cronar tape to provide 13-channel program of up to 282 minutes duration. Accuracy is ±25 ms or ½% of 1%, whichever is greater. Readout reliability is above 99.999%. Compact unit (Fig. 12) is not affected by magnetic fields.

An *interval timer* can use a synchronous motor to drive the time indicator only during the elapsed time one wants to measure.

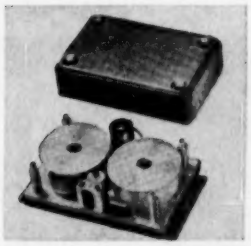


FIG. 12. BEATTIE-COLMAN punched-tape timer.

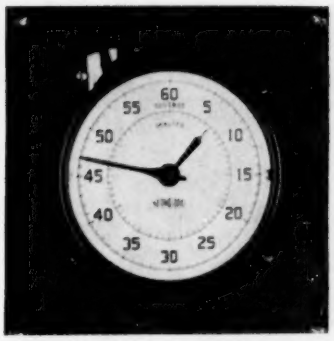


FIG. 14. STANDARD ELECTRIC Time Co. panel-mounted timer.

FIG. 16. HOBBS d-c hour meter.

FIG. 17. FEDERAL Pacific elapsed-time indicator.

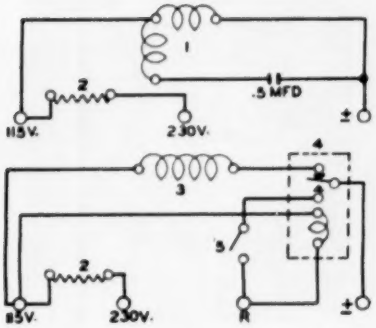


FIG. 13. TIMER starts when clutch (3) is energized. Synchronous motor (1) runs continuously.

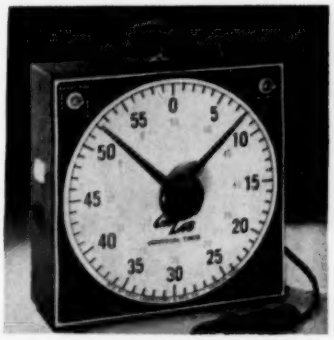


FIG. 15. DIMCO-GRAY universal timer.

FIG. 18. MARION elapsed-time indicator.

The synchronous motor runs continuously (Fig. 13). To operate, the timer is first reset to zero. A lever, or solenoid returns the hands to zero. The timer is now ready to operate. When the clutch is energized, the hands are driven by the motor. When the clutch is de-energized the hands are disconnected from the motor and indicate the time interval that the clutch was energized. Opening and closing time can be adjusted to make the start and stop error equal and compensating. Such an interval timer is shown in Fig. 14 (Standard Electric Time Co.)

An interval timer (Dimco-Gray) that provides timed power from 1 minute to 60 hours is shown in Fig. 15. Alarm sounds and external load is switched (on or off) at end of time interval. Portable and panel-mounting types have ranges 1 sec to 60 min, ¼ sec to 15 min, etc. Dimco-Gray interval timers are available for 110 or 220 v, 50 or 60 cycle operation with time ranges from 60 seconds to 60 hours.

The hour meter, or running-time meter, or elapsed-time indicator is used to record total running time of any powered equipment. Hours meters can be supplied for operation on alternating current or direct current. The d-c meter shown in Figure 16 (John W. Hobbs Corporation) registers up to 10,000 hours in 1/10-hour increments, and operates through an escapement mechanism. Synchronous-motor-operated a-c hour meters are available in the nominal voltages of 120, 240, and 480 volts.

Federal Pacific offers elapsed-time counter-indicators (Fig. 17) for hours up to 9999.9 or 99999. Self-starting synchronous motor has 4-watt rating. Case can be round or square, 2½" or 3½".

Marion 53 Series elapsed-time indicators (Fig. 18) have self-starting synchronous motors and 5-digit registers to indicate hours to 99999 or hours and tenths to 9999.9. The 53 Series are suited for indicating operating time of electrical equipment or machine tools where hermetic sealing against fumes, dust and moisture is unnecessary and low cost is a primary consideration.

Type 471 time-delay relay of Cramer Controls Corp. (Fig. 19) provides an adjustable time delay between the operation of a control circuit and the subsequent closing or opening of one or two load circuits. It is powered by a synchronous motor which drives timing cams through a direct-acting or a reverse-acting clutch. In the direct-clutch model, applying power to the motor circuit auto-

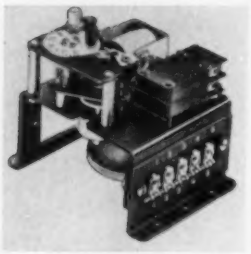


FIG. 19. **CRAMER** time-delay relay.

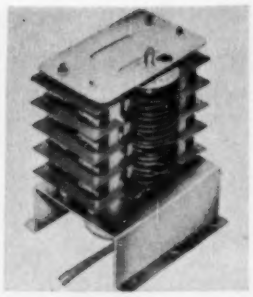


FIG. 20. **CRAMER** program timer.

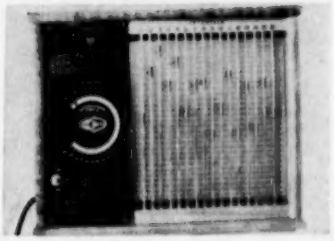


FIG. 21. **BALD** Eagle Interchrom interval timer.

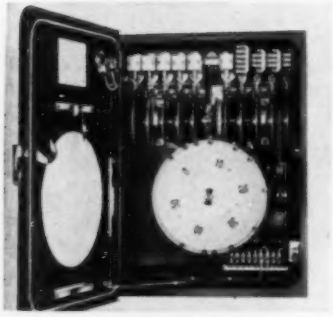


FIG. 22. **BRISTOL** CIC500 cycle controller.

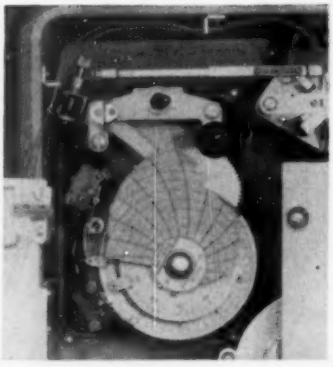


FIG. 23. **BAILEY** program controller.

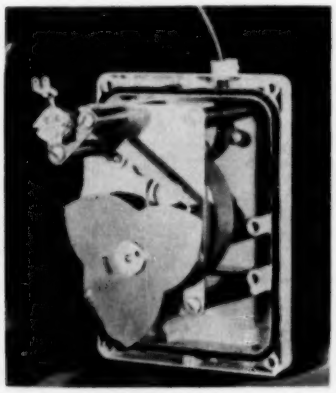


FIG. 24. **BAILEY** running-time recorder: cam makes one revolution each hour.

matically engages the clutch, and timing starts at once. In the reverse-clutch model, motor and clutch are on separate circuits, and applying power to both circuits will start the motor but will hold the clutch disengaged until the clutch circuit is broken, at which point the clutch will engage and timinig will start.

Resetting is accomplished by a coil spring which drives the cam carriage back toward a movable stop. The position of this stop determines how long it will take the motor to drive the cams forward to the switch actuation points, and thus sets the timed interval. Time ranges are from 15 seconds to 24 hours, in 11 ranges. Repeatability is within 2%. SPDT switches are rated at 10 amperes 125 v or 5 amperes 250 v ac, resistive load.

Fig. 20 shows a program timer (Cramer Type 521) featuring cam operation. Accuracy is 1½° of rotation.

Interval timers, cyling timers, running time meters, pulse timers also are available from Cramer.

Sequence timing of 16 intervals in succession can be performed by the Interchron Timer of Bald Eagle Corp. (Fig. 21). Each interval can be set independently from 10 sec to 30 min with 10-sec scale division steps simply by sliding a rider along a bar. The timer is operated by synchronous motor. Timer can be modified to perform on-off timing intervals in a set sequence.

Industrial cycle controllers are timing instruments which actuate a combination of pilot valves (pneumatic or electric) at precise intervals and in predetermined sequence, for industrial or general control applications. Fig. 22 shows the Bristol CIC500 cycle controller. The timing disc rotates continuously until the cycle of operations is completed. Dogs on the periphery of the disc can be set at the precise times that each pilot is to operate. Each dog trips a switch which energizes a cam-drive motor (lower right of case). The motor drives the series of cams. The cams are driven forward to the station at which the pilot is to operate. At this point a pin on the index cam stops the cam-drive motor. Each pilot can be operated in any sequence. Timing disc speeds are available from 15 min to 360 min, with minimum divisions of 5 sec to 2 min.

A program controller can control process variables (adjust set point) according to a predetermined time program. Fig. 23 shows a clock-driven profile cam (Bailey Meter Co.) that is geared to make one revolution every 1, 4, 6, 8, 12, 24 hours, or every 7 days. Time can be indicated by tracking pen back and forth across a chart. The

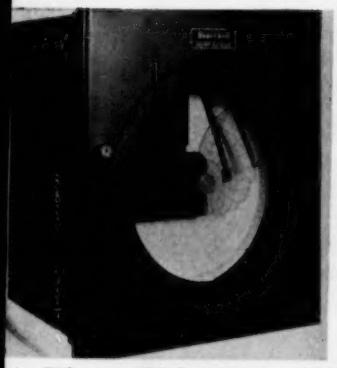


FIG. 25. **BROWN** cam program controller.

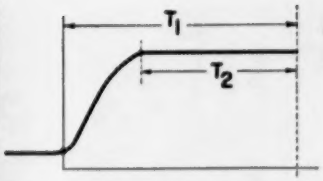


FIG. 27. **ELAPSED-TIME** controller can measure total time (T_1) or measure elapsed time after control point is reached (T_2).

FIG. 28. **FOXBORO** cook-time and cool-time controller for canning industry.

FIG. 26. **FOXBORO** cam-set controller.

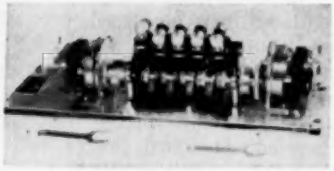


FIG. 29. **ELECTRIC** Switch Model 635 uses two motors to provide two different speed cycles.

pen reverses its direction at regular intervals. Fig. 24 shows the cam operator of such a running-time recorder (Bailey Meter Co.) Each rise and fall section of the cam takes 10 minutes; one revolution in one hour. Accuracy is within ±6 seconds.

Brown Instruments Div. of Minneapolis-Honeywell Regulator Co. cam programmers are circular-chart controllers with a cam follower connected to the index pointer (Fig. 25). The cam follower rides on a stiff cam cut to the same process pattern desired in the controlled variable. In both the thermometer and ElectroniK potentiometer models, the cam is turned by its own motor, so that changing and resetting of cams will not interfere with the chart drive, nor will chart replacement interrupt processing. The cam is printed with the same time and and temperature markings as the chart; it is easy to mark and cut each section for the desired time, temperature, and rate of change. Brown cam programmer thermometers are available as single-cam, duplex, and dual-cam models. Duplex means that two cams turn on the same shaft, while dual-cam models feature an independent drive motor and shaft for each cam.

Foxboro Cam-Set Controller (Fig. 26) controls a process schedule according to the contour of a rotating cam. A timer can be added to the cam-set controller to stop the control cycle at a set elapsed time. In addition to the dual-case recording model shown, the cam-set controller is available as a single-case recorder-controller.

Foxboro elapsed-time controllers have adjustable time periods. In the M/40E-A controller the controller the elapsed-time period starts when the control valve is first opened; the valve closes and the process shuts down at the end of the elapsed time period (T_1 in Fig. 27).

In the M/40E-B controller (with deferred action) the elapsed-time period does not start until the measurement reaches the control point for the first time (T_2 in Fig. 27).

In canning control, the variables which affect the quality of the product include temperature, pressure, and time of cook and time of cooling.

The heart of the Foxboro Retort Unit Control System is contained in the subpanel shown in Fig. 28.

Fig. 29 shows a time-cycle controller using motor-driven cams and mercury switches, offered by Electric Switch Corp. Two motors provide two cycle speeds. The slower motor usually programs a series of operational cycles and can signal the faster motor to take over the drive of the cam shaft (through overriding clutches) and activate another definite program. The faster motor is deactivated (upon completion of its cycle) and the drive of the controller is returned to the slower motor.

Features available with electric switch Staley time-cycle controllers include:

1. Electromagnetic brake assembly, which prevents coasting when the drive motor is de-energized for extremely accurate timing.
2. Compound tandem gear assembly, which allows two cam shafts to be driven at different speeds by the same motor.
3. Four available switch arrangements—SPST, DPST, SPDT, DPDT.

Thermal Time Delay

In a thermal relay the load contacts open or close in response to the heating effect of an energizing current.

The thermal relay has a number of advantages. It is smaller and lighter than other types of electrical time-delay devices, can be hermetically sealed, requires no lubrication or other maintenance, and its simple construction make it reliable and trouble-free. The thermal principle generally results in lower power consumption than in other types of devices performing similar functions; it can operate on d-c or a-c of any frequency. Following an ener-

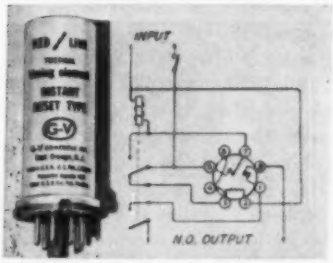


FIG. 30. A SHOWS G-V THERMAL time delay. B shows G-V Type DM instant-reset thermal element.

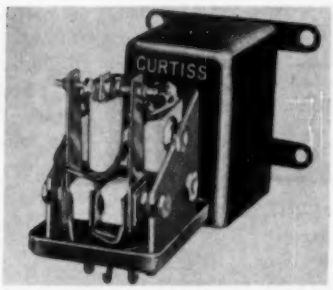


FIG. 31. CURTISS-WRIGHT thermal time-delay relay.

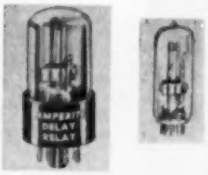


FIG. 32. AMPERITE standard and miniature thermostatic delay relays.

FIG. 33. AGASTAT dial-head time-delay relay.

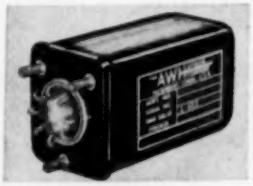


FIG. 34. A. W. HAYDON R-C time-constant delay.

gized period, the cooling time of the relay can be used to produce a time delay after cut-off of electrical energy.

Thermal relays can be used for sensing voltage or current levels and operating output contacts if these levels exceed or fall below predetermined levels for a selected time interval.

It also has limitations. It must ordinarily cool after one-time delay action, before it is ready to repeat. Thus instant reset requires additional components and circuitry. Also, accuracy is seldom better than 5%.

The rate of heating, and consequently the delay interval, varies with change in energizing voltage. Additional circuitry can get around this problem.

Fig. 30,A shows the G-V controls hot-wire time-delay relay, which uses a thin wire to obtain short delays (fraction of a second). A ribbon under tension can be used for longer delays and a rigid expanding member can be used for delays of 10 seconds or longer.

The G-V Type DM Instant-Reset Thermal Element (Fig. 30, B), when combined with a small magnetic relay (which is ordinarily supplied by the user), provides instant-reset time delay in a reliable and economical form. Time delays from 5 seconds to 6 minutes can be supplied. Heater voltages cover the range from 6.3 to 230 v. Output circuits are insulated from input circuits.

Fig. 31 shows a typical thermal time-delay relay (Curtiss-Wright Model STR), which features instantaneous resetting contacts, ambient-temperature compensation. Uses are reported in sequential timing, delay of application of plate voltage, overload protection, computer sequencing, transistor protection, etc.

Amperite thermostatic delay relays (Fig. 32) are actuated by a heater; they can be used on ac dc, or pulsating current. SPST contacts are available—normally open or normally closed. Heater voltages are from 2.5 to 115 v. For short delays (1 to 10 seconds) a low-voltage heater (6.3 v) is recommended. Standard heater voltages include 6.3v, 26v, 115 v. Other voltages available to 2.5, 5.0, 12.0 and 50 v. For 200 v, use a 115 v relay with a dropping resistor of 6500 ohms—5". Delays available are from 2 to 180 seconds.

Agastat time delay relays (Fig. 33) are offered in two types. In Type 1 the time delay starts when the coil is energized providing a delayed make. When the coil is de-energized the break is instantaneous.

In Type 2 make is instantaneous upon energizing the coil. Time delay starts when coil is de-energized, delaying the break.

Single-and multiple-circuit contacts can be normally open or normally closed. A dial head provides delay adjustment.

Contact capacity can be to 200 amperes at 115 v. Voltage ratings are to 440v. Timing ranges are from 0.08 second to 3 seconds, to 30 seconds to 15 minutes. Repeatability is to ±10%.

R-C Constant

Transistorized time-delay relays are available in which R-C time-constant networks provide the time

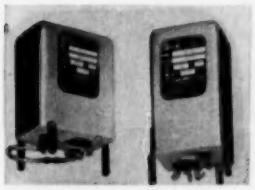


FIG. 35. G-V 4-oz time-constant delay.

FIG. 36. ATC short-interval delay timers. A shows military model; B shows industrial model.

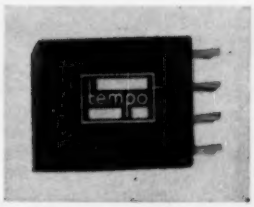


FIG. 37. TEMPO timing module.

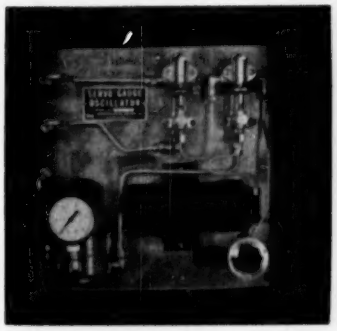
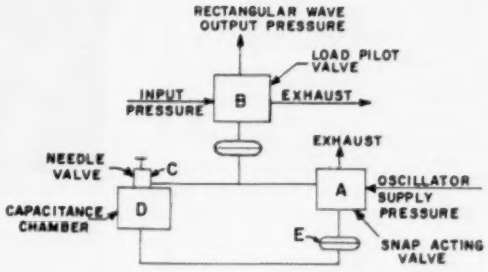


FIG. 38. SERVO GAUGE oscillator (left) and block diagram (right).



interval. Fig. 34 shows the A. W. Haydon Co. 31200 series, featuring 2.5% accuracy and a time-delay interval of 50 ms to 15 minutes.

G-V Controls Inc., Types 401 and 404 Transistorized Time Delays (Fig. 35) use an R-C constant plus a transistor. Delay interval is adjustable over a 10-to-1 range, and five overlapping ranges cover the span from 0.1 sec to 300 sec. Time delay is determined by the value of a resistor connected between two external terminals. Under the worst combination of voltage (18 to 30 volts) and —55° to +125°C), the variation does not exceed ±8% for delays up to 30 seconds and ±10% for longer delays.

Fig. 36, A shows the Automatic Timing & Controls transistorized, mil. spec. short-interval delay timers featuring timing circuit with R-C time-constant network. Ranges are 50 ms to 5 minutes. With built-in voltage regulation, accuracy is ±3%. The timing circuit operates on a R-C time constant network principle, with built-in voltage regulation repeatability is ±3% of range.

Fig. 36, B shows the industrial model with ranges from 0.02-to-1 sec, to 1-to-120 sec. Repeatability is within 1%.

Tempo Instruments offers a line of building block modules (Fig. 37) for timing and control, based on an R-C timing network, a (transistor) gate and a load. Pulse train generators, intervalometers, etc., can be made up from the modules.

Pneumatic (RC) Timer

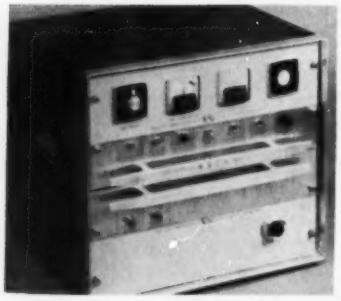
The Servo-Gauge Oscillator (Fig. 38) is a pneumatically actuated timer that sends out, on a predetermined time cycle, a repetitive air signal impulse. The frequency and amplitude (pressure) of the output signal are independently adjustable while in service. Unit is made by Associated Control Equipment, Inc.

Principle of operation is shown in Fig. 38. The load pilot valve (B) alternately connects the load to the regulated input pressure or exhausts it to atmosphere. This delivers a train of square-wave output pressure pulses to the load. The load input pressure can be set manually by a regulator, or it can be varied by an automatic pneumatic controller.

Valve (B) is operated by the bellows below it. The dead-band, 3-way oscillator pilot valve (A) alternately connects this bellows to a regulated (oscillator supply) pressure or exhausts the bellows to atmosphere. The reversal frequency is determined by the bleed rate through needle valve (C). While the pressure is on the load valve bellows, the needle valve (C) permits pressure to rise in chamber (D). This chamber pressure is always applied to the bellows (E). When chamber pressure becomes sufficient, bellows (E) operates the snap-acting valve. Now the chamber pressure bleeds off through needle valve (C) to atmosphere. When chamber pressure falls, bellows (E) again permits the snap-acting valve to connect the system to the oscillator supply pressure and the cycle is repeated.

Electronic Timing

For highest timing accuracy, electronic methods using oscillator-counting techniques are used. A new technique for synchronizing widely-separated objects (such as cameras at ballistic-missile



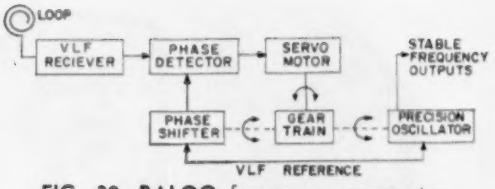


FIG. 41. **HERMES** precision timing system.

FIG. 39. **RALOC** frequency comparator.

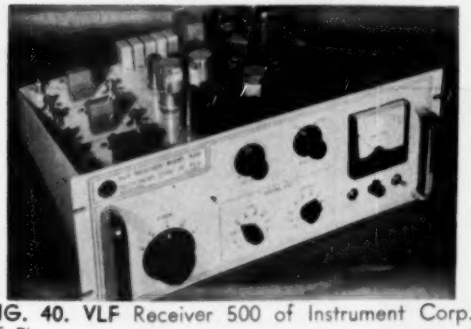
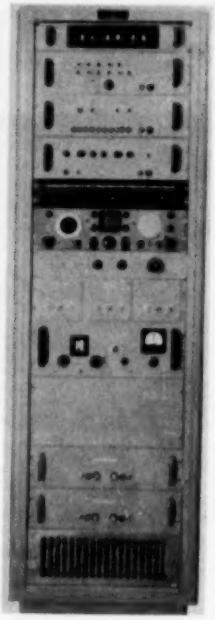


FIG. 40. **VLF** Receiver 500 of Instrument Corp. of Fla.

FIG. 43. **NORTHEASTERN** Engineering frequency calibrator.



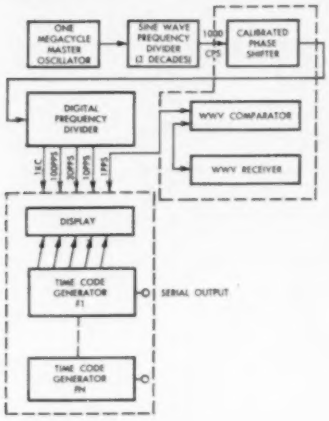


FIG. 42. **BLOCK** diagram of Hermes

tracking stations) is phase-shift measurement of VLF radio-frequency transmissions.

A very accurate precision frequency comparator and long-term frequency standard is "RALOC" of Pickard & Burns (Fig. 39). It operates on the fundamental principle that when two signals are of precisely the same frequency, their phase relationship will remain constant over any period of time. Conversely, if the two signals are of slightly different frequencies, there will be an accumulation of phase difference which is directly related to both the frequency difference and the time period of measurement. The precision of the system is due to two factors: (1) the RALOC phase comparison system is sensitive to very small differences in phase; and (2) the highly precise transmissions of VLF stations NBA and GBR are distorted much less by propagation than are the standard frequency transmissions of high-frequency stations.

As shown in the simplified block diagram (Fig. 40) the transmissions of the primary standard (NBA or GBR) are received by a sensitive, low-noise VLF receiver. The phase of the received signal is then compared with the phase of the signal derived from the precision oscillator. A servomechanism (consisting of servo motor, gear train and phase shifter) locks the frequency of the derived signals to that of the received transmission, at the same time indicating the absolute magnitude of any phase difference which may exist. Simultaneously, the servomechanism automatically adjusts the oscillator to phase coherence with the received transmissions. Outputs are 1 Mc or 100 kc.

As a frequency comparator, RALOC permits comparisons to the primariy standard of 1 part per 10^9 within one hour or less. Longer periods of measurements permit closer comparisons, to 1 part per 10^{10} or better. As a frequency standard, RALOC maintains continuously and automatically an accuracy and stability of ± 5 parts per 10^9 relative to internationally-controlled primary standard transmissions.

VLF Time-and-Frequency Receiver Model R500 (Fig. 40), made by Instrument Corp. of Florida, is a pre-tuned unit adjusted to receive signals from five stations operating in the 14-30 kc band—NSS, NBA, GBR, NPM, and NPG. Of these stations, GBR and NBA operate with stabilized frequency and time control good to at least small parts in 10^{-11}.

For time measurement the signal is heterodyned against a precision controlled oscillator that is offset from the received frequency by 1000 cycles. The 1000-cycle beat note can be displayed on an oscilloscope, recorded on magnetic tape directly, or used to synchronize a time clock. Time measurement accuracy to approximately 500 microseconds can be expected. Under ideal conditions, this can be improved to 100-microsecond accuracy.

An output also is provided for phase measurement of a local ultra-stable oscillator by comparison in a precision phase detector and recorder.

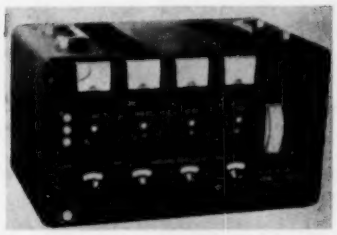


FIG. 44. MEASUREMENTS standard frequency meter.

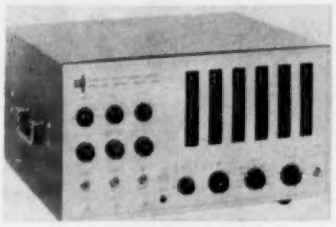


FIG. 45. COMPUTER-MEASUREMENTS universal counter-timer.

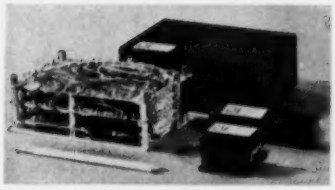


FIG. 46. GENERAL Time "Incremag" timer-programmer with oscillator.

The VLP Phase Comparator R500-1 is designed to use the signal from the Model R500 Receiver and make a precise comparison against a local oscillator source. The phase difference appears as microsecond difference on a chart recorder.

Phase measurement accuracy depends on the length of the recording period. Measurements accurate to small parts in 10^{-11} can be expected if the recording period is at least 24 hours. For normal oscillator adjustments, a four-hour measurement, which results in one or two parts in 10^{-10} has proven adequate for most applications, such as synchronizing (or timing) several missile-tracking stations.

Precision timing systems are required for tracking and control of missiles. Fig. 41 shows the Hermes Electronics Co. Precision Timing System incorporated in missile range instrumentation to provide time reference for correlation of events and accurate measurement of missile positions and performance. This timing system is composed of a number of pieces of equipment as shown in Fig. 42. The heart of any precision timing system is the master oscillator which serves as the time base. A WWV receiver and comparator corrects for drift error of the time-base oscillator over long-time periods. The time-code generators generate time codes either as sequential clock pulses or binary-code form, to be fed directly to magnetic or photographic recording equipment.

In timing work involving high-speed counters, a frequency calibrator is often needed. Fig. 43 shows the Model 14-31 of Northeastern Engineering featuring stability of 5 parts in 10^8/wk. It uses a 100-kc high-stability sine wave. Accuracy is better than 1 part in 10^6 in 90 days.

A standard frequency meter also is useful in many timing operations. Fig. 44 shows the Measurements Model 700 Standard Frequency Meter. It features crystal accuracy at all frequencies and, when referenced to a prime standard such as WWV, will measure to within ±20 cycles—less than 0.0001%. Accuracy is ± one cycle with an external audio counter. It will measure frequencies up to 1000 megacycles.

Counter-timers are in general and growing use for measurement of time intervals of microseconds, as well as measurement of frequency, phase shift, period, etc. Fig. 45 shows the Model 226B of Computer Measurements Co., a typical counter timer featuring a time-interval measurement of 1 microsecond to 10^6 seconds with a time-interval accuracy of 1 microsecond.

Timing has been effected electronically by dividing a known frequency to the desired time base. An oscillator, or a source of pulses, is required. One method of division uses a magnetic core that can be magnetized incrementally to give an output after a fixed number of pulses, thus acting as a time delay or a time lapse device.

The Incremag* (made by General Time Research Laboratory) is such a counter (Fig. 46). It will count either periodic or random input pulses at a rate of up to 100,000 per second. As many magnetic cores may be cascaded as required to get the proper division. The accuracy claimed for this device is that of the frequency of the pulse source. It is all solid-state materials; long life can be anticipated.

An accurate remotely-settable interval timer can be assembled from a predetermined pulse counter, a precision gated stepping switch, and an accurate pulse source (Fig. 47).

Any time interval from 1 second to 999 seconds can be remotely set into the system. If the remote pulse source is a Repeat Cycle Timer driven by the A. W. Haydon Company's Chronometrically Governed Motor, the system accuracy can be ±1/10 of 1% of the maximum setting.

*Reg. Trade Mark

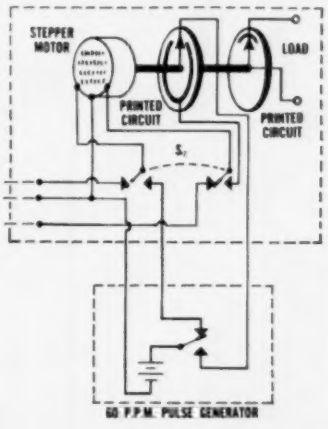
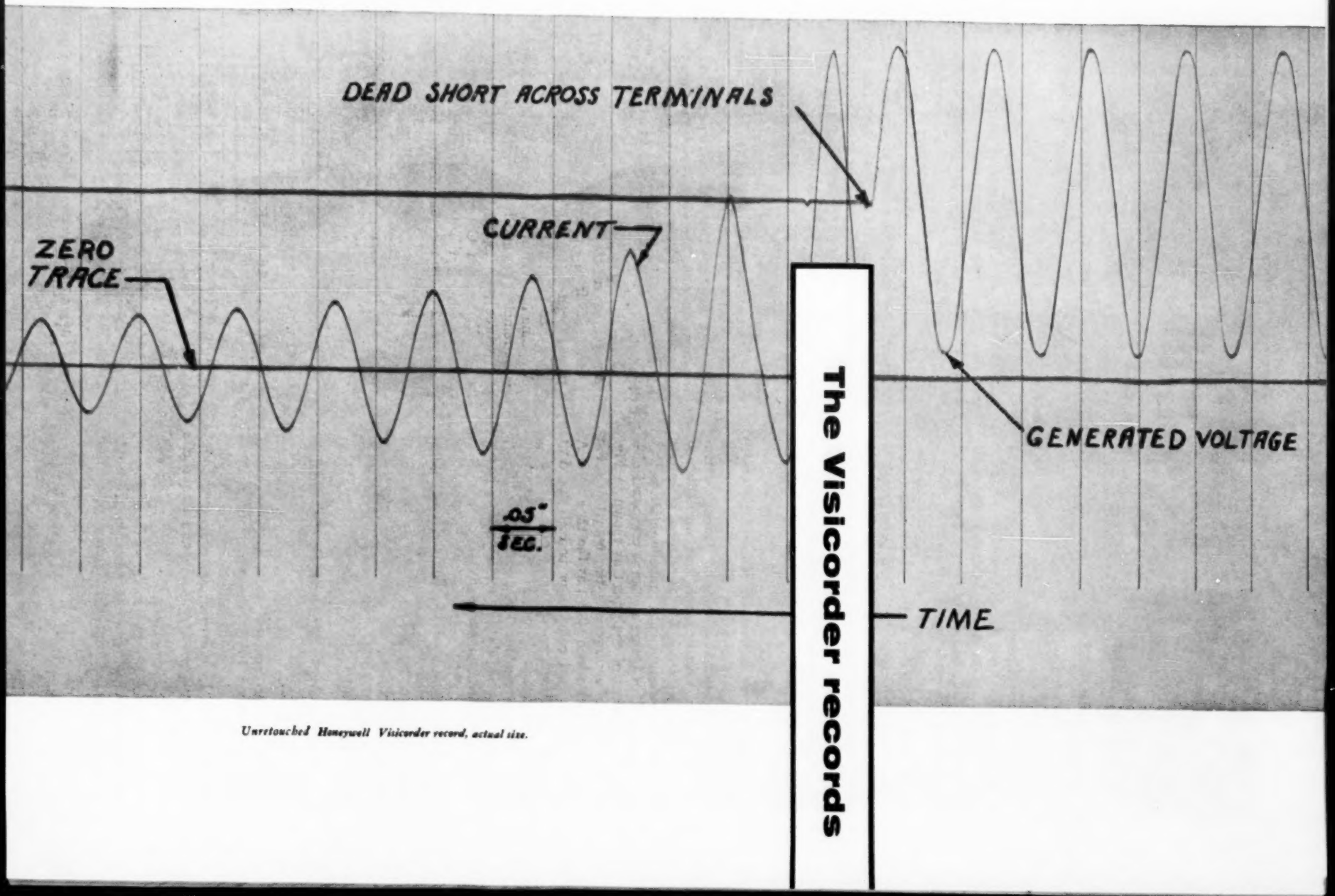


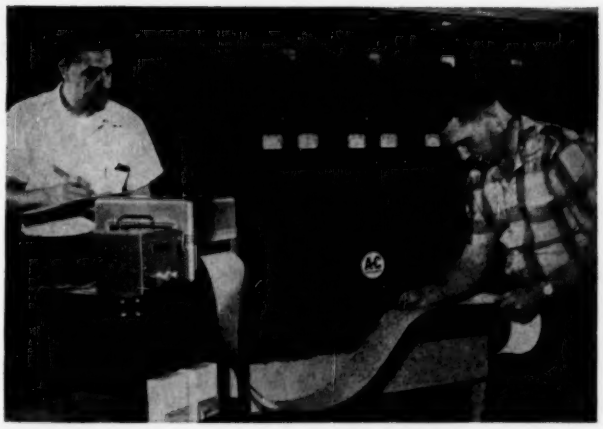
FIG. 47. PULSE source and stepping switch provide delayed switch action.



Unretouched Honeywell Visicorder record, actual size.

This study of the drop in voltage load on an Allis-Chalmers alternating current generator was directly recorded by a Model 906 Honeywell Visicorder.

In this transient reactance test, made by design engineers at the Allis-Chalmers Norwood Works, the generator was operated at full voltage, and then a dead short was applied to the terminals. When such a sudden load is thrown upon a generator, the voltage drops because of the inherent characteristics of the generator. This voltage "nosedive" is so rapid that a voltage regulator cannot immediately correct the voltage and bring it up to normal. Because of this time delay while the regulator is catching up, motor contacts and other devices on the line may drop out, lights may blink objectionably, and electronic devices may function erratically. For these reasons, these studies of time as related to generator characteristics are very important to better generator design. The Visicorder's ease of operation, calibration, and immediate readout made it ideal for these studies.



N. O. Risch and F. R. Manning, design engineers at Allis-Chalmers Norwood Works, study a Visicorder chart of voltage-drop tests on a generator.

generator voltage load-drop

The Honeywell Visicorder is the pioneer, completely proven, and unquestioned leader in the field of high-frequency, high-sensitivity, direct-recording ultra-violet oscillography. Here are some of the reasons why Visicorders provide the most accurate analog recordings available: constant flat response and sensitivity of galvanometers; grid-lines simultaneously recorded with traces to guarantee exact reference regardless of possible paper shift or shrinkage; flash-tube timing system for greater accuracy of time lines; superior optics for maximum linearity of traces.

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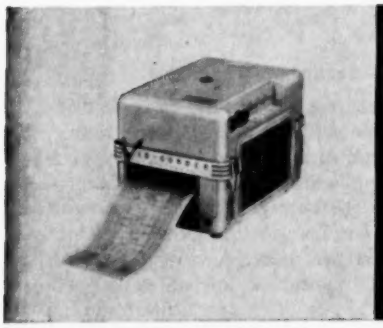
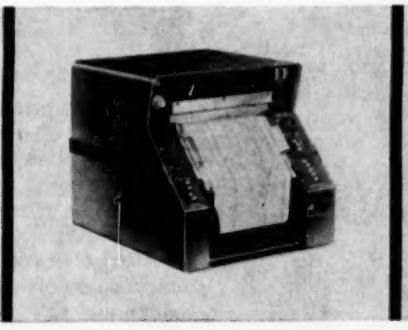
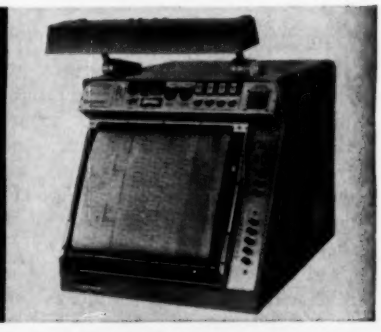


Recent Models of the 906 Visicorder incorporate time lines and grid lines and record up to 14 simultaneous channels of data.



The NEW Model 1108 Visicorder, with many automatic features and the convenience of pushbutton controls, is ideal for intermediate uses requiring up to 24 channels of data.



The Model 1012 Visicorder is the most versatile and convenient oscillograph ever devised for recording as many as 36 channels of data.

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CIRCLE 86 ON READER-SERVICE CARD

Program Timers

Timing devices are finding an ever-increasing use. Here are comparative characteristics of various timer configurations—motor driven, spring actuated, air driven, electromagnetic and electronic controlled.

G. GORTEN*, R. JOHNSON, R. SMITH
Daystrom, Incorporated
Pacific Division

THE HEART of any timing device is in the drive because the accuracy of the entire instrument cannot exceed the accuracy of the driving member or prime mover.

Normally, a constant-speed (or nearly constant-speed) drive is required to actuate the timing mechanism. Where motors are used, their speed is closely regulated by governors or constant-voltage or constant-frequency power sources. For other drives, mechanical escapements are often necessary to achieve the desired regulation.

Motor-Driven Timers

Synchronous motors generally are used to drive timers which have a timing range greater than 1 minute. Motor speed is as accurate as the frequency of the power source, and instantaneous error is small. Output torques are normally between 2 and 75 in-oz at a speed of 1 rpm. The motor speed is not affected by ordinary voltage fluctuations, although the time to reach synchronous speed can cause a timing error. Clutches often are used with the motor running continuously to reduce this error.

Induction motors are sometimes used when high starting-torque is required and synchronous accuracy is not required. Here, speed varies with load and frequency. Capacitor-start, capacitor-run and shaded-pole motors are used most often. Induction motors can be freed from frequency and load variations over a reasonable range by using a centrifugal governor. This requires a wound rotor (instead of the usual squirrel cage) and the shorting of the rotor windings through the governor contacts.

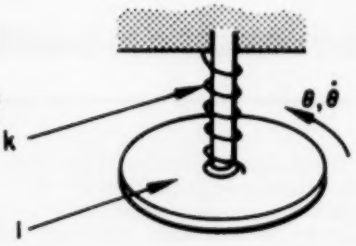


FIG. 1. Timing by mass acceleration.

Direct-current motors are used where high torques and low time-constants are desired. Constant speed dictates shunt-wound motors, but the permanent-magnet types are usually smaller and cheaper. Speed will vary with voltage, load and temperature, but can be regulated by a centrifugal governor.

Spring-Actuated Devices

Spring-escapement mechanisms can provide driving torque where electric power is unavailable. Frequently, this type of device is used in expendable single-cycle applications, although mechanical reset can be provided for repetitive use. Intervals can be controlled from a fraction of a second to intervals of a month or more. Accuracy depends on precision of manufacture, temperature compensation, and external load characteristics. Pendulum escapements are accurate but bulky and are best suited for stationary applications. Spring movements are limited by low and irregular torque, although special design can improve these conditions.

Basically a spring can drive a timer by one of two methods. One is to accelerate a mass (usually in rotation) by an initial spring impulse until it reaches essentially constant speed. Then the constant speed can be used much like that derived from a regulated or governed motor.

The second method (Fig. 1) makes use of the

*Presently with Litton Industries

time interval during which the mass is being accelerated, and depends on the expected speed variations during this interval to accomplish the timing. If the spring drives a symmetrical commutator or cam, the mating wiper or switch contact location must, of course, be spaced with regard to the equation which governs the speed variation. For example, a torsion spring can drive a commutator disc which contains functional circuit segments etched on its circumference. These segments are contacted by brushes or wipers for some desired portion of the total circumference. In this type of device the time required to accelerate a disc or cylinder through a specified angle is utilized as the timing function. The relation of the driven member's inertia to the available spring torque establishes the timing cycle by using the transient rather than steady-state effect of the mechanism.

Air-Driven Timers

High-speed air-turbines are employed sometimes to drive a gear train regulated by an escapement. Application is where electric power is unavailable or in explosive atmospheres where sparking may be hazardous. Electrical hermetically-sealed timers solve the sparking hazard but are not adjustable.

Typical output torques for air-driven devices are 2 to 8 in-oz at 1 rpm for operating pressures of 20 to 25 psig and an air consumption of 0.1 cfpm.

Electromagnetic and Electronic Devices

Crystal Oscillator

A quartz crystal oscillator can be used with a gated counter circuit. Often electronic multiplying and dividing circuits are added to give amplification for higher and lower frequencies. Errors can be held as low as 1 part in 10^8 if stable electronic components are used and if temperature, barometric pressure, voltage and loading are controlled closely.

Tuning-Fork Drive

When ambient conditions are regulated closely, a tuning-fork timer can yield an output frequency which is constant within 1 part in 10^5. The fork is driven by an electro-magnet. Output is taken from a second electromagnet which is excited by the fork vibration. The device is controlled by a tube or transistor which operates a relay. Timing can be adjusted by clamping the fork at different points. The resonant frequency of the fork and its material must be selected carefully to minimize the hysteresis as well as frequency drift due to material fatigue.

RC Networks

Capacitor charge or discharge timer types use the characteristics of voltage and current transients in an RC network. In a capacitor discharge device, for example, voltage drops to 37% of initial value after a time equal to the product of R and C. Timing is adjusted by varying resistance or capacitance. Accuracy depends on constancy of charging voltage and component characteristics.

If the capacitor operates the load directly, delay time is limited by the required capacitor size (using the capacitor voltage to provide a signal for a tube or transistor overcomes this limitation to some extent). Possible disadvantage is that momentary power loss causes immediate return to initial condition. When power is reapplied, the cycle starts from the beginning without completion of the original cycle.

Relays

Relays have many diversified applications as timing devices. Basic types of relays are (1) the standard telephone-type relay, (2) the inertially damped relay, and (3) the thermal relay.

The *standard telephone-type relay* provides two techniques for timing. One is the adjustment of the various combinations (fast, normal and slow) of operate and release time through the electromagnetic circuit. Typical is the *flux decay type* in which the armature operates contacts to control the start of the timing cycle. A d-c electromagnet with a heavy copper ring or highly inductive shorted coil is located inside the main coil. When the circuit opens, magnet drop-out is retarded by the current induced in the copper slug. The (L/R) time constant of the slug determines the sequence time cycle. Disadvantages are sensitivity to vibration, shock and temperature variation, and comparatively short time-intervals. Advantages are simplicity, long life, and reliability under normal environmental conditions.

The second telephone-type-relay timing technique employed is the selection of the precedence of opening and closing related contacts. That is, the logic of using various combinations of "make-before-break", "break-before-make" and others provide additional options as to specific timing sequences that may be provided in the standard telephone-type relay.

An *inertially regulated relay* uses weights added to the armature of an a-c or d-c relay to increase inertia and cause time delay. When shock, vibration or change in position affect operation, the armature can be pivoted to achieve a balanced condition. Inertia effect can be varied by changing the armature's travel. Time intervals are usually fixed but can accommodate adjustable stop pins. Accuracy of inertial timers is approximately 5%, with a rather low timing range (0.08 to 2.0 seconds).

The *thermal time-delay relay* operates on either ac or dc; it uses the expansion rate of a bi-metallic strip to open or close the desired contacts. Accuracy depends on ambient temperature variation, voltage fluctuation and elapsed time between successive operations. These units offer the advantage of low cost and silent operation. They are relatively unaffected by variation of line frequency. Errors are usually in the 5% to 10% range. Intercoupling circuits decrease the off time required between successive cycles.

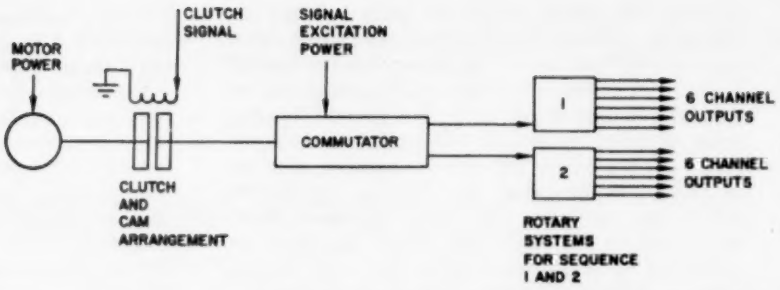


FIG. 2. INTERVALAMETER T30C-2 is motor driven.

Fluid-damped Timers

Liquid damping devices use a solenoid, lanyard, fuse, spring or squib to start the timing function. A-c or d-c solenoid armature motion is retarded by fluid passing the plunger. For rapid cycling, quick-return check valves are used. These devices are affected by temperature changes because repeatability requires a constant-viscosity fluid. Silicone oils have been used successfully for applications where ambient temperatures vary from −30° to +120°F.

Air-damped devices use the time required for a fixed volume of air to pass through an orifice or restriction. Cycles are adjustable by a needle valve, and a solenoid armature is used to start the time interval. The armature of the solenoid can be attached to a diaphragm and its movement retarded by the rate at which air flows through the restriction. Such a design is unaffected by ambient temperature variations but must have exacting filter control to prevent contamination of inlet air.

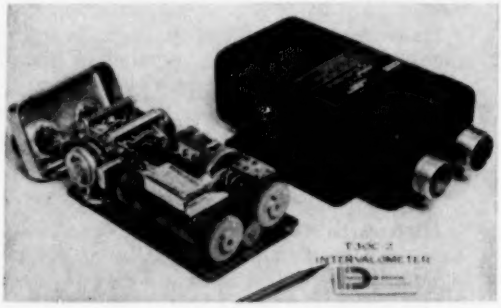
Common Considerations

To provide output pulses it is common to use contact action, including cylindrical commutators, etched discs, cams, notches, actuating arms, and embossed or notched tapes which actuate switches or make contact directly upon mating brushes or wiper contacts either in a rotating or linear movement. Potentiometers can be driven to alter the bias and thereby trigger transistor switching circuits. These elements are usually driven through a gear train or other mechanical linkage to obtain the desired time relationship and required torque. At times, interconnecting clutches can couple or uncouple the timing contacts from the main actuating source. Automatic or manual reset mechanisms can be employed to index the device for start of a new program cycle.

Rotary selector switches can provide output routing of time functions. There are other types and combinations of timer elements, but the types discussed are used most widely. Among those applied rarely are escapement-regulated motors, inertially damped motors, photocell switches, and solenoid-driven rack and gear escapement mechanisms. Sometimes, specific requirements demand the use of these devices.

Typical D-C Motor-Driven Timer

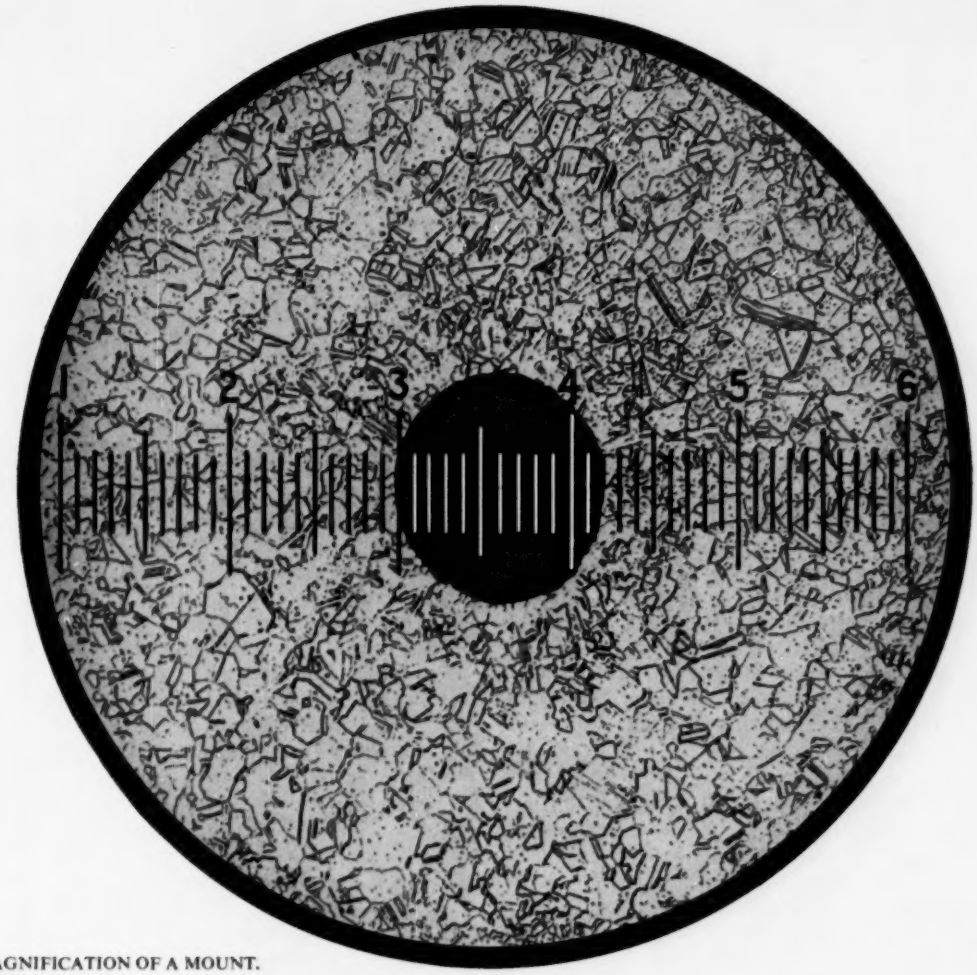
The Daystrom Model T30C-2 Intervalometer (Fig. 2) is a D-C motor-driven timer providing 6 channels and 2-sequences. Motor excitation is required five seconds before first signal is applied so that the desired speed can be established by means of a governor. When the clutch coil is energized, the clutch is actuated and the motor drives the commutator contacts through one revolution to execute Sequence 1. The clutch will remain energized even if the original signal is interrupted. As the commutator cage completes one revolution (one sequence) a cam removes power from the clutch. This allows the motor to continue rotating without being coupled to the commutator cage. The cam arrangement also provides a mechanical stop to prevent the cage inertia from causing overshoot, stopping the cage rotation after precisely 360° of rotation and indexing it for the next cycle.



This action is identical for Sequence 2, except that different contacts are involved. No time-delay relays or relay cascades are used in this design; pulses pass only through commutator segments and contacts on rotary solenoid switches.

Typical Pulse-Controlled System

The Daystrom Airborne Temperature Recording System Model AB10A-1 scans inputs from 50 thermocouples, feeds alternate thermocouple signals to one of two self-balancing potentiometers which then convert the signal to digital form. These signals are transmitted through a code-conversion matrix and fed into a tape punch mechanism. The basic timing pulses are provided by a synchronous motor which drives a cam switch. These pulses are then used to synchronize the movements of the three electromagnetic stepping switches in four various modes of operation.



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CIRCLE 87 ON READER-SERVICE CARD

Time Standards

A. G. McNISH, National Bureau of Standards

THE POSSIBILITY of embodying our unit for time in a physical constant is attractive. We can measure time, and its reciprocal, frequency, with the greatest precision of any physical quantity. For example, we can compare the ratio of the average frequencies of two oscillators over concurrent time intervals with as great a precision as we choose. The limit is set by how long the oscillators will operate and how many cycles we wish to count, but such comparisons are pointless if the frequencies of the oscillators are not relatively stable over the interval involved. Conversely, we may measure time with equal precision by counting cycles of a particular oscillator, assuming its frequency is constant.

There is a serious problem in measuring time accurately. We can lay two meter bars side-by-side and compare their lengths. If, by subsequent comparisons, we find their lengths have not changed relatively we have confidence that our length standards have not changed. But there is no way to lay two time intervals side-by-side; we must rely on the stability of an oscillator to compare time intervals. Man-made oscillators show drifts in frequency with respect to each other, and since oscillators are not passive things like meter bars and kilogram weights, we expect them to drift.

To obtain a good standard for time and frequency we adopted first an astronomical constant, the rotational frequency of the earth, which had been regarded as constant since the days of Joshua. Man-made oscillators were used to interpolate for shorter intervals of time and the second was defined as 1/86400 of a mean solar day. As the apparent solar day varies throughout the year due to eccentricity of the earth's orbit, astronomers kept track of time by observing star transits, in relation to which earth's rotation is much more uniform.

Precise astronomical observations revealed that this standard was not good enough. The frequency of rotation of the earth is changing with respect to the revolutions of the moon about the earth and the earth about the sun, when allowance is made for perturbations of the revolution time. All planetary motions are in substantial accord. In addition to a gradual slowing down, which is to be expected from tidal friction, there are erratic fluctuations in rotational speed. For this reason astronomers carry out their more precise calculations in *ephemeris time*, which is based on planetary motions.

With the improvement of quartz-crystal oscillators, seasonal fluctuations in the earth's rotation with respect to the stars have appeared. Though the oscillator frequencies drift, they drift monotonically, allowing us to measure these seasonal fluctuations, which amount to 1 part in 10^8. Correcting for this seasonal fluctuation, astronomers have established a more uniform time scale, called UT2, good to 1 part in 10^9, tied in with the earth's rotation, and hence subject to effects of long-term changes.

So we see that even the smoothed rotation frequency of the earth is not good enough for a standard. Accordingly the second was redefined in 1956 by the International Committee on Weights and Measures as 1/31556925.9747 of the tropical year 1900.0 at 12 hours ephemeris time. Why this strange definition? Why not take the sidereal year or the anomalistic year? The lengths of all these years change in known, highly regular ways, so that specification of any epoch was necessary. We chose the tropical year, which is the time between two successive passages of the center of the sun across the celestial equator in the same sense, because accurate tables were already available for its variation, based on the epoch 1900.

The need for a better standard of time became urgent during the past decade with the improvement in microwave techniques. Microwave terms in the spectra of molecules and atoms were being measured with increased precision. The Bureau began to explore these phenomena as the basis for constructing more stable oscillators. Before 1952 Lyons and his co-workers at the Bureau had measured the microwave resonance in the ground state of the cesium atom with a precision of 1 part in 10^7. Essen and his co-workers at the National Physical Laboratory a few years later increased this precision to a few parts in 10^{10}. It is likely that greater precision can be attained in measuring the cesium frequency and also other atomic frequencies such as those of rubidium, as was indicated by recent work of Bender and Beaty of the Bureau and Chi of the Naval Research

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Abstracts from paper "The Basis of Our Measuring System," *Proceedings of the IRE*, May, 1959.

Laboratory. As the frequencies of these resonances depend on energy levels of the atoms involved, and as, in the case of the cesium, independent experiments have agreed to within the limits of precision, we may presume that they can serve well as standards for time and frequency.

How can we relate these resonance frequencies to the defined unit of time, the ephemeris second? As the second is defined by an event which occurred over 50 years ago we must measure the resonance frequencies in terms of current values of the UT2 second, and then, through observations on the moon, relate the UT2 second to the ephemeris second. This was done recently, based on four years of observation of the moon, showing that the ephemeris second corresponds to 9,192,632,770±20 cycles of the cesium frequency. This is much less precise than the defined value of the second or the precision with which the cesium resonance can be observed.

We have no hope of relating the atomic resonances to the ephemeris second with much greater precision in the near future. We thus are faced with the fact that atomic constants are much better standards for time and frequency than astronomical constants. Furthermore, as standards they are much more accessible than the astronomical constants, which require long years of observation to compare them precisely with other quantities. Clearly, we are able today to improve our standard for time by selecting one of the atomic resonances and defining the second in terms of it, making the definition such that the new definition will agree as closely as feasible with the present one.

The frequencies broadcast by the Bureau's stations WWV and WWVH are now monitored and kept as constant as possible by reference to the cesium resonance. The intervals between the seconds pulses are maintained in the same way. Therefore the seconds pulses gradually get out of step with mean solar time. When the difference becomes great enough the pulses are shifted by exactly 20 milliseconds to bring them back in. Thus we are already using two kinds of time, atomic time—for the scientists—and mean solar time—for the birds and other diurnal creatures.

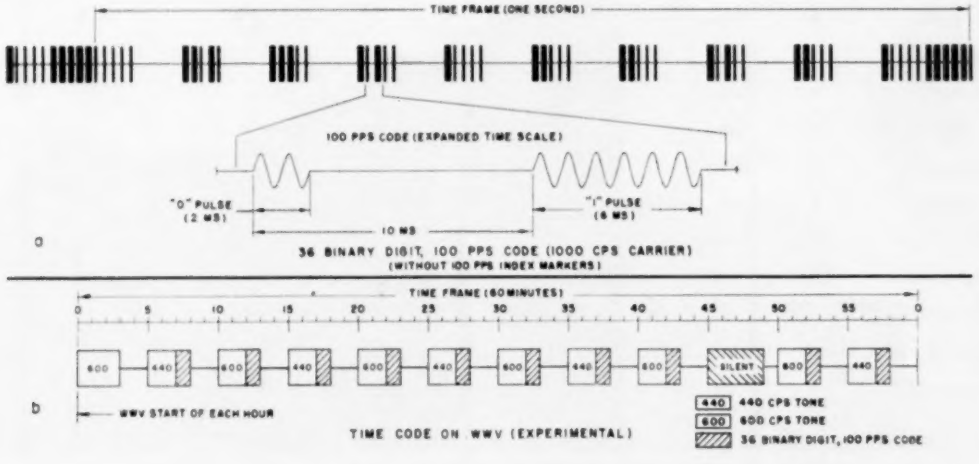
These attempts to improve time and frequency measurement may seem a quest for precision for precision's own sake, a futile pushing of the decimal point. But this is not correct. It is an attempt to establish standards so that we may learn what physics lies beyond the decimal point. For such things have Nobel Prizes been awarded. We have already learned that the earth turns irregularly on its axis. Now we ask, do time scales based on astronomic, atomic, and molecular processes change with respect to each other as some think they might? (The ammonia maser depends on molecular processes for its frequency stability.) Perhaps from these newly achieved precisions and those soon to be achieved we may even be able to resolve experimentally the famous clock paradox of relativity.

Time Code on WWV

NATIONAL BUREAU OF STANDARDS radio station WWV is now broadcasting an experimental time code of 36 bits at 100 pulses per second (PPS) on 2.5, 5, 10, 15, 20, and 25 Mc.

The code (binary-coded decimal) is broadcast for 1-min intervals and 10 times per hour. Except at the beginning of each hour, it immediately follows the standard audio frequencies of 440 and 600 cps. The latter frequencies are given alternately as below, except the duration is 2 min instead of 3 min when the code is given. A complete time frame is 1 sec.

The code contains time of year information (UT) in seconds, minutes, hours, and day of year.

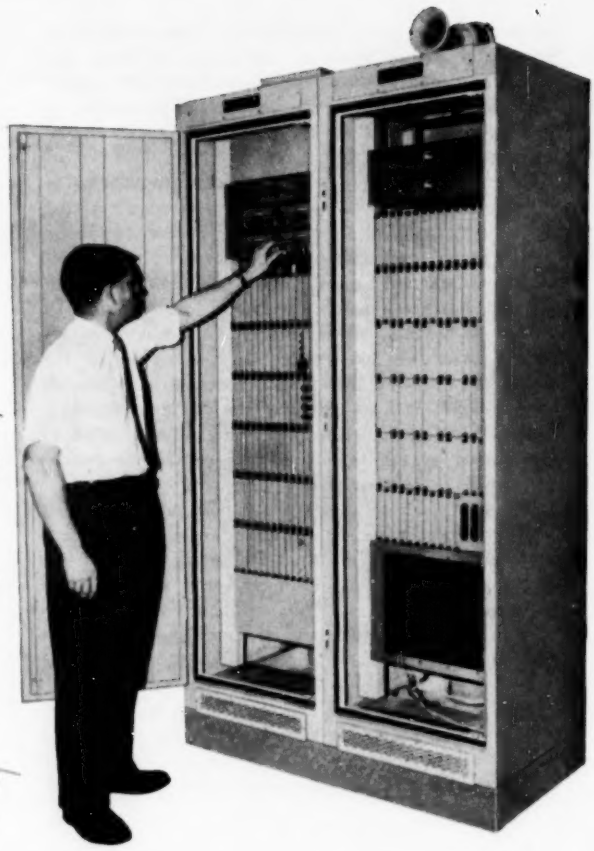

TIME FRAME (ONE SECOND)
100 PPS CODE (EXPANDED TIME SCALE)
"0" PULSE (2 MS)
"1" PULSE (5 MS)
10 MS
a
36 BINARY DIGIT, 100 PPS CODE (1000 CPS CARRIER)
(WITHOUT 100 PPS INDEX MARKERS)
TIME FRAME (60 MINUTES)
0 5 10 15 20 25 30 35 40 45 50 55 0
600 440 600 440 600 440 600 440 600 SILENT 600 440
b
WWV START OF EACH HOUR
440 440 CPS TONE
600 600 CPS TONE
36 BINARY DIGIT, 100 PPS CODE
TIME CODE ON WWV (EXPERIMENTAL)

KEY to functions performed by Bailey 700 Systems

A — Analog **D** — Digital **A/D** — Analog and Digital **s** — sense and measure
d — display (indicate, record and/or log)
m — monitor (scan and alarm)
p — produce stored information for future use (tape, cards) **c**—compute **r**—control

● Installed ● On order

	LOCATION	TYPE	FUNCTIONS
1.	Chelan Co., Wash.	D	sdm
2.	Chelan Co., Wash.	D	sd
3.	San Francisco	A	sdc
4.	Salinas, California	A	sdc
5.	Los Angeles	A	sdc
6.	Glendale, Ariz.	A	sdc
7.	Alameda, N. M.	A	sdc
8.	Amarillo, Texas	A/D	sdmc
9.	Smithers Lake, Tex.	A	sdr
10.	Orange Co., Tex.	A/D	sdmcr
11.	Bronte, Tex.	D	sdm
12.	Sioux Falls, S. D.	A	sdr
13.	Oklahoma City	A	sdc
14.	Harrah, Okla.	A	sdc
15.	Muskogee, Okla.	A	sdc
16.	Lafayette, La.	A	sdc
17.	Jackson, Miss.	A	sdc
18.	Cleveland, Miss.	A	sdc
19.	Memphis, Tenn.	D	sdm
20.	Paducah, Ky.	D	sdc
21.	Sullivan, Ind.	A	sdc
22.	Graham, W. Va.	A	sdc
23.	Ashtabula, Ohio	A	sdc
24.	Monroe, Mich.	A	sdcr
25.	Rochester, N. Y.	A	sdc
26.	Ludlowville, N. Y.	D	sdmp
27.	Buchanan, N. Y.	A	sdr
28.	Fairless Hills, Pa.	D	dm
29.	Wilmington, Del.	D	dm
30.	Washington, D. C.	D	dp
31.	Hamilton Twp., N. J.	A	sdr
32.	N. S. Savannah	A	sdr



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Pressure Standards Lab

CHARLES E. WHITE, AVCO Research and Advanced Development, Wilmington, Mass.

Here are the instruments used and the resultant measurement accuracy capability (shown at bottom of each block in illustration) of the pressure calibration section of one of the country's finest standards and calibration facilities. The EM numbers in third column of table 2 refer to the tests indicated in lower-left corner of each block in illustration showing the test set-ups.

TABLE 1—PRESSURE MEASUREMENTS ACCURACY CAPABILITIES

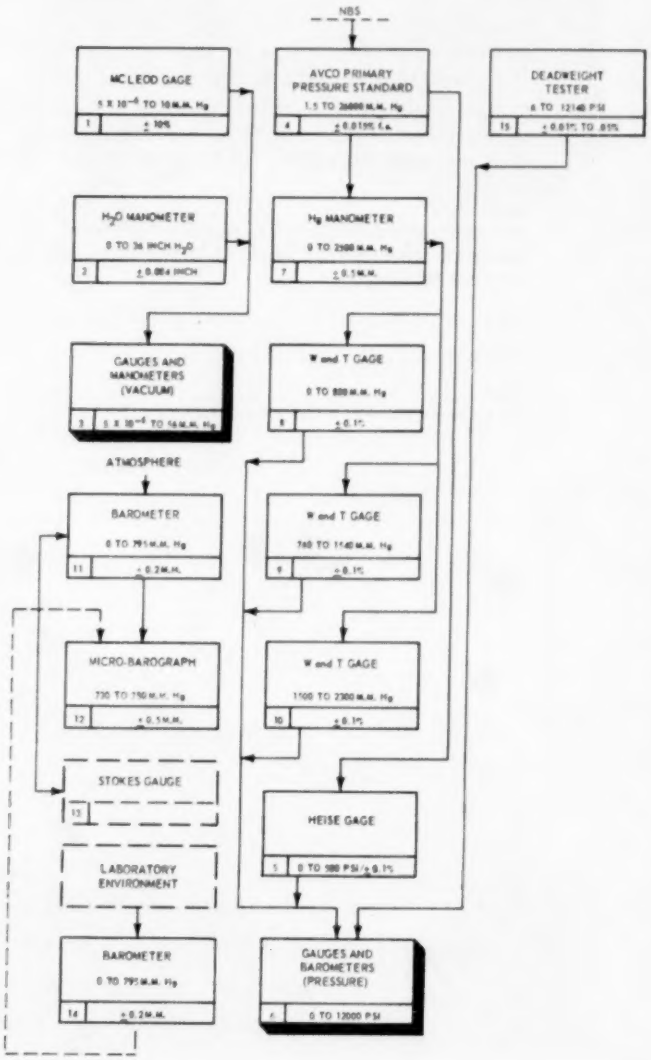
PRESSURE (Abs)	ACCURACY	INSTRUMENT
0.005 micron - 1.0 mm Hg	±10%	McLeod Gauge
0 - 30 in of water	±0.004 in H_2O	Water Manometer
0 - 100 in of Hg	±0.025 in Hg	Mercury Manometer
0.3 - 50 psi	±0.01 psi	Dead-weight tester
50 - 500 psi	±0.125 psi	Dead-weight tester
500 - 2417 psi	±0.25 psi	Dead-weight tester
2417 - 12140 psi	±0.25 - ±6.5 psi	Dead-weight tester

TABLE 2—PRESSURE CALIBRATION INSTRUMENTATION

ITEM	MANUFACTURER AND MODEL	APPLICATION
Barograph, Micro	BED 790-1	EM12
Dead Weight Tester	ASA 1300	EM6
Dead Weight Tester	ASA 1313A	EM6
Gage, 12" 500 psi	HED - 500	EM5, 6
Gage, Dead Weight	RUD 2400 HL	EM15, 6
Gage, McLeod	CEA 94156	EM0
Gage, McLeod	STJ 278AC	EM1
Gage, Pressure	WAA FA145	EM48
Indicator, Diephragm, Differential Pressure	RUD 2406	EM15
Indicator, Humidity	SEF 201	EM0, E29
Indicator, Pressure	HAJ SP-1	EM1
Manometer	MED 34EH10-P47201	EM2
Manometer, Barometer	HAC 10-00-00-F	EM11, 14, 12
Manometer, Controller-100"	IDA 11-17-100	EM7, 6, 10
Manometer, Prec. Gauge	WAA FA129	EM8
Manometer, Prec. Mercury	WAA FA135	EM0
Manometer, Water	KIA BUB36	EM2
Manostat	WAA FA149	EM6, EM0
Pressure Standard	COE 6-201	EM4, 6, 5
Pump, Vacuum	CEA Hypervac	EM11
Pump, Vacuum Duo Seal	FIB 1405H	EM1, 2
Pump, Vacuum Duo Seal	WEI 1392A	EM3
Regulator, Pressure	MOI 43-20, 40-39, 40-50	EM1, 4

TABLE 3—CODE OF MANUFACTURERS

ASA—Ashcroft Div./MM&Moore, Stratford, Conn.
BED—Bendix Eclipse Pioneer, Teterboro, N. J.
CEA—Central Scientific Co., Chicago, Ill.
COE—Consolidated Electrodynamics Corp., Pasadena, Calif.
FIG—Fisher Scientific Co., Chicago, Ill.
HAC—Haas Bros., Washington, D. C.
HAJ—Hastings Raydist, Hampton, Va.
HED—Heise Bourdon Tube Co., Newton, Conn.
IDA—Ideal Aerosmith, Cheyenne, Wyo.
KIA—King Engineering Corp., Ann Arbor, Mich.
MED—Meriam Instrument Co., Cleveland, Ohio
MOI—Moore Products, Philadelphia, Penna.
RUD—Ruska Instrument Corp., Houston, Texas
SEF—Serdex, Inc., Englewood, N. J.
STJ—Stokes, F. J. Corp., Philadelphia, Penna.
WAA—Wallace & Tiernan, Belleview, N. J.
WEI—Welch, Wm. Mfg. Co., El Segundo, Calif.



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STANDARDIZED TESTS FOR BALL BEARINGS?

A. H. MASCHMEYER
Autonetics
North American Aviation, Inc.

Unlike torque testing, there has not been any effort to standardize bearing vibration characteristics, the instruments for their measurement, nor even the units used in expressing the measurement.

CONVENTIONAL quality specifications for precision ball bearings are usually expressed in terms of quality class designations of the Annular Bearing Engineering Committee (ABEC) of the Anti-Friction Bearing Manufacturers' Association. The ABEC classification controls only the *external dimensions* and their associated tolerances. However, the ability of the bearing to perform its expected function depends primarily on the *internal characteristics* of the bearing, which conventional specifications ignore.

Although minimum internal friction is often considered the key factor in precision instrument bearings, there are many applications where consistency in friction level from bearing to bearing is more important than an extremely low level of friction.

The inherent friction level of a bearing is determined by measuring the torque required to turn the outer race of the bearing with respect to the inner race. Bearing torque can be considered under two headings—starting torque and running torque.

Torque Testers

Several instruments can measure bearing torque. With *starting-torque-measuring instruments* the bearing is mounted with its rotating axis vertical and the inner race stationary. The outer race is free to rotate and supports a standard weight of 75 or 400 grams (depending on bearing size), which applies a controlled thrust load to the bearing under test. Torque is then applied gradually to the outer race until rotation begins. The amount of torque applied at this point is recorded and the bearing is permitted to coast to a stop. Torque is applied again and the starting torque again recorded. Ten such readings are taken and, as the bearing is allowed to coast to the next reading position, reading positions are assumed to be random selected. Despite the time consumed, the results are often questionable and correlation is difficult if not impossible. Repeatability between readings on the same bearing between different instruments is also extremely difficult.

Running-torque testers also hold the bearing with its rotating axis vertical and apply a pure thrust load of 75 or 400 grams depending on the bearing size. The outer race is continuously rotated at a specified speed while the instantaneous driving torque is continuously detected by a transducer which feeds its electrical output through an amplifier to a recorder.

A straight line produced on the chart indicates a bearing with absolutely uniform torque. With the present state of the art, the recorded traces always show deviations from this ideal condition. Torque traces are useful for diagnostic purposes when correctly interpreted. For example, lubricant drag is indicated by a steady displacement of the trace to one side or the other of the zero torque position. Large displacements of the trace usually indicate separator "hang-up" or ball and separator interference. Low-amplitude and irregularly spaced pulses result from contamination, while a regularly spaced pulse indicates the presence of a brinell mark, dent, or scratch on one of the raceways. A low-amplitude sinusoidal trace usually indicates lack of parallelism between the raceways and the sides of the races. A sinusoidal trace can also result from lobed raceways.

An attempt to standardize torque testers has been made by a committee sponsored by the American Ordnance Association and the Department of Defense. This work has resulted in the release of MIL-STD-206, Friction Torque Testing for Instrument Ball Bearings, Part 1 and 2. This specification establishes functional and calibration requirements for torque-testing instruments and also covers testing-procedure criteria.

Bearings which are torque tested according to MIL-STD-206 are required to be rotated through 360 degrees in one direction and then 360 degrees in the other at a maximum speed of 0.5 rpm. These requirements create a slow test procedure not suitable for production testing except on a sampling basis. Obviously, as the test rotational speed is increased the detail of the trace decreases. Some bearing manufacturers operate torque testers at speeds up to 25 rpm which, although it somewhat improves the testing time, leaves much to be desired when large quantities of bearings are to be tested and good sensitivity is desirable. The primary value of present-day torque testers is in analytical and diagnostical work. The application of torque testers to production testing must be limited to sampling unless the increased cost can be justified.

Vibration Testers

Another category of tester used to determine the functional characteristics of precision instrument bear-

ings is the so-called *vibration tester.* Vibration-testing instruments are responsive to the vibration or noise induced by a freely rotating bearing. Although vibrator testers are not responsive to the torque characteristics of a bearing, it can be said that the same type of defects which develop internal bearing friction are usually the same defects which produce the vibration and noise to which the vibration testers are sensitive. Consequently, considering unloaded bearing, there is a distinct but as yet undefined relationship between the results of a torque test and the results of a vibration test. It is reasonable to conclude that low vibration levels mean lower opposition to pure rotation, high performance and longer life.

Unlike torque testing, there has not been any effort to standardize bearing vibration characteristics, the instruments for their measurement, nor even the units used in expressing the measurement. Some use velocity-sensitive pick offs, others are displacement sensitive; there are large differences in the response frequencies of the transducers and also differences in the manner in which the information is displayed. Each bearing manufacturer uses his own vibration tester and his own nomenclature for expressing the vibration.

Realizing the need for standardized vibration testing, Autonetics, a Division of North American Aviation, Incorporated, inquired of the American Ordnance Association what action had been taken or planned in standardizing vibration tests. A reply from the chairman of the AOA Instrument Precision Ball Bearing Section said, in effect, that after canvassing the Industry, the Section Committee decided that it was an impossible task to standardize vibration characteristics and correlate the various instruments presently used.

The writer feels that the impossibility of the task is not due to technical difficulties. The problem is rendered difficult by the fact that most of the major bearing manufacturers have large investments in their own testers, and realize that standardization may obsolete some instruments.

A possible solution to this progress-hindering impasse would be the appointment of an *ad hoc* committee composed of representatives of bearing *users.* Bearing manufacturers, or manufacturers of vibration testers would be excluded to maintain an impartial attitude. This committee would investigate the relative merits for the instruments test procedures, calibration methods, and units of measurement to be used and, from their findings, develop the necessary standard.

Standardized vibration testing would enable the bearing users to express their requirements in an industry-accepted and understood language. Standardization would establish units of measurement and identity which, through common usage, would be advantageous in evaluating and predicting the quality of bearings for critical applications.

Most components used in complex instrumentation systems have standardized functional tests with which their system and environment capatability can be evaluated and their reliability appraised. Such tests exists for all electronic components; why not for precision bearings? Are they considered less critical? It should be realized that catastrophic results from failure of an electronic component often can circumvented by redundant design practice. Bearings are not amenable to such practices and failure is nearly always associated with complete loss of the instrument and subsequently, the aircraft or missile or process.

Ferroelectricity with Ferrimagnetism

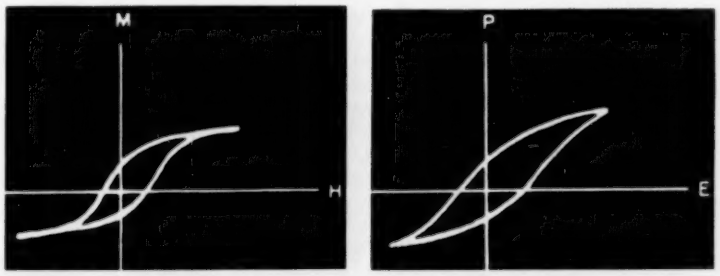


FIG. 1. MAGNETIC (left) and dielectric (right) hysteresis loops of the barinum niobate compound.

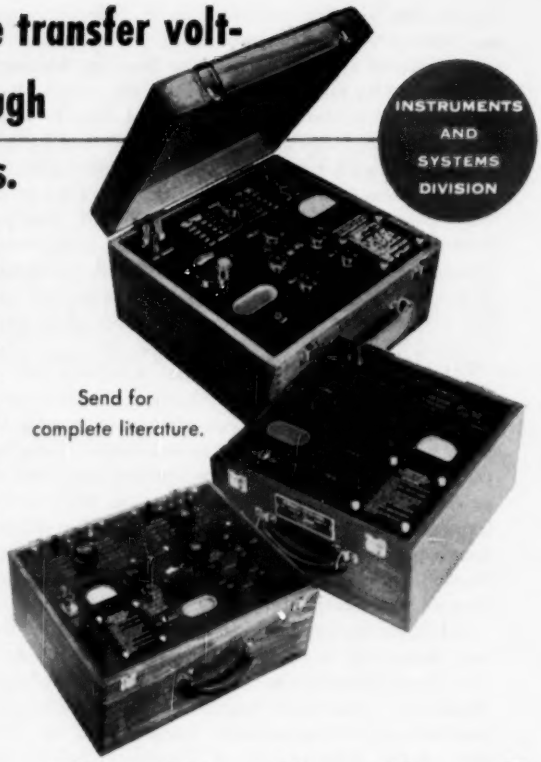
NATIONAL BUREAU OF STANDARDS has discovered a ceramic that has both ferroelectric and ferrimagnetic properties. The generalized composition is a barium niobate containing any one of several rare earths plus iron oxide, and has a single-phase crystalline structure. As the two properties seem to be mutually dependent, the composition should find application in new electronic components where a coupling between dielectric and magnetic effects is desirable, or where a magnetic material having a high dielectric constant would be useful.

P. H. Fang and R. S. Roth of the Bureau's mineral products laboratory postulated the existence of the material and then examined nearly 90 dielectric compositions before finding one with both types of properties. Once this composition was discovered, additional similar structures were postulated by substituting other atoms at appropriate locations in the crystal.

Ferroelectric properties have been confirmed by the presence of the dielectric hysteresis loop and the piezoelectric resonance. The piezoelectric effect was measured on a polarized ceramic disk. Ferrimagnetic properties are verified by the presence of the remanent magnetization and the effect of the replacement of different rare earth ions on the ferrimagnetic Curie temperature.

HERMACH-ENGELHARD multi-range transfer volt-ammeter with 0.05% accuracy through a frequency range d-c to 50,000 cps.

INSTRUMENTS AND SYSTEMS DIVISION



This multi-range instrument satisfies the exacting calibration requirements over a wide range of currents and voltages. High accuracy is attained without use of correction factors.

The functional design of this transfer standard, employing the null principle, provides operation sufficiently simple for non-technical operators. Results are read on the external d-c potentiometer in a conventional way and multiplied by convenient round numbers to give measured current or voltage to 0.05%, without correction, continuously over the frequency spectrum from d-c to 50,000 cps. To achieve the accuracy which the Hermach-Engelhard Transfer Volt-Ammeter provides across the whole audio frequency range, a whole battery of the usual measuring devices would be needed.

To provide efficient adaptability to various conditions of application, several models can be obtained. They are portable, simple and economical to maintain.

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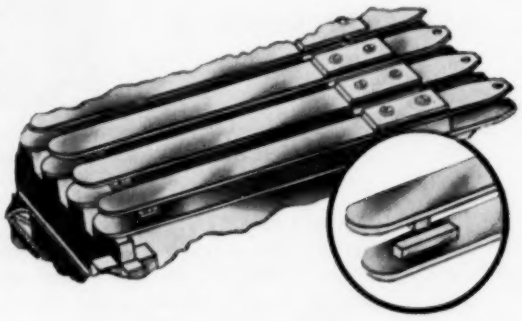

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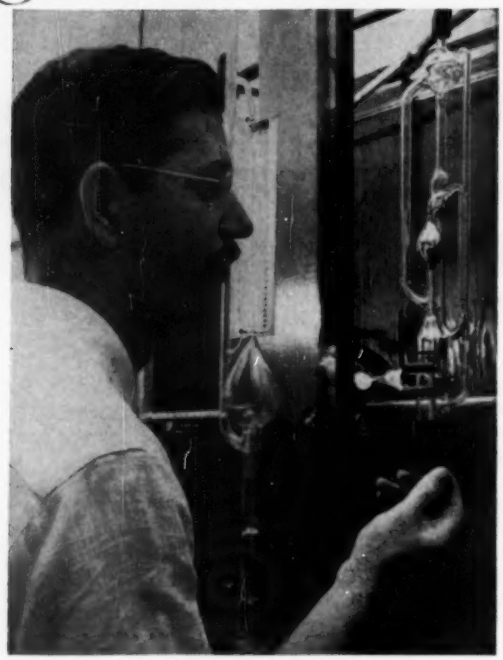


FIG. 1. IMPROVED McLeod gage.

Improved McLeod

Closed-end capillary of the conventional McLeod gage is difficult to keep clean. Now an open capillary can be used to measure low pressures; the gas is compressed in the capillary by a mercury surface at both ends.

MCLEOD-TYPE GAGE (Fig. 1) operates on the pressure-volume principle established by Boyle. A fixed volume of the rarefied gas is trapped in the gage by mercury. This gas is trapped and compressed by the rising mercury to a smaller volume read on the indicating tube. The pressure on the trapped gas must be equal to the difference in level of the mercury in the center indicating tube and the outside compensating capillary. Boyle's Law is used in calibrating the scale. Thus, by knowing the initial volume and by reading final volume and pressure, the initial pressure can be calculated*.

Perhaps the greatest difficulty encountered with use of the conventional McLeod gauge is the problem of keeping its closed-end capillary clean and free of mercury slugs. The main purpose of this new design is to eliminate this annoyance; the closed-end capillary is replaced with an open capillary. Another problem encountered with the conventional gage is raising and lowering the mercury level in order to compress the trapped gas.

The new design controls the mercury level by means of a rubber O-ring-sealed piston operating in a precision-bore tube, which permits rapid and precise readings in combination with compactness.

Gage Construction

The mercury reservoir consists of a 1" I.D. medium-wall precision-bore pyrex tube with a polished flat and square flange. A rubber "O" ring on the face of the flange insures a high vacuum seal. Riding inside of the cylindrical reservoir is a stainless-steel piston with a rubber O-ring seal. A threaded stainless-steel stud permits micrometer adjustment of the rod near the upper end of its travel.

The volume of the bulb from the cut-off point *D* to the fiduciary mark *C* is 11.50 ml. The small bulb above the large bulb has a volume of 1.015 ml between the marks *C* and *B*. The capillary leading from the small bulb is precision bore and has a diameter of 1.153 mm (using 0.0454" drill rod). The volume between the marks *B* and *A* is adjusted to 0.0200 ml. The gas sample is trapped by the rising mercury above the plunger when the mercury crosses point D (the intersection of equalizing tube

* $$P = \frac{(v_o + ah)h}{V - v_o - ah}$$

where P = system pressure, V is volume between points A and D, v_o is volume between A and B and A and C, h = drop of mercury column below point A, a = cross-sectional area of capillary.

Presented before the Division of Physical Chemistry at the 136th meeting of the American Chemical Society, Atlantic City, N. J.

Gage

ROGER GILMONT
Manostat Corporation

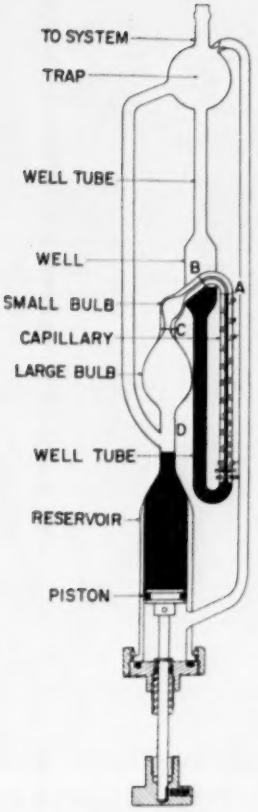


FIG. 2. GAGE ready for operation.

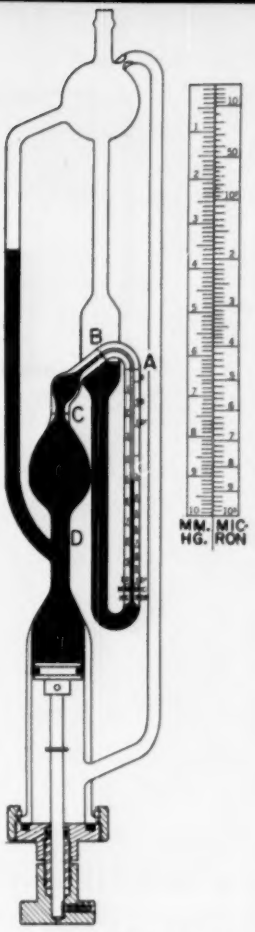


FIG 3. READING on the micron scale.

and the calibrated volume). The trapped volume is that between points D and A (Fig. 2).

Method of Operation

With the piston in its fully retracted position and the instrument vertical, clean dry mercury is added to the trap through the system connection. The mercury will run down into the well, up the capillary and siphon over through the bulbs into the reservoir. When the mercury level reaches the top of the reservoir (about an inch below the cut-off point *D*), no more mercury is added. Approximately 30 ml of mercury are required to fill the instrument. When the siphon breaks, the level of the mercury in the capillary should be close to point *A*. If it is below this point, mercury should be added to the well; if it is above, mercury should be removed. The latter can be accomplished by tilting the manometer until the desired amount of mercury siphons into the bulbs, and then by restoring to the vertical to break the siphon. The final level established by the well must bring the capillary level exactly at *A* (Fig. 2).

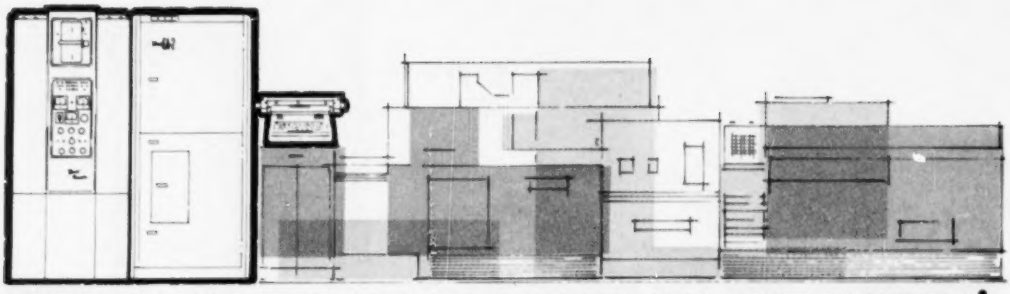
The instrument is now connected to the system; position is vertical. When vacuum is first put on the instrument, trapped gases in the mercury will be liberated. After these gases are removed the instrument is ready for taking a leading. The piston is slid up into the reservoir by pushing the handle. When the handle engages the first thread of the stud, the mercury level should be slightly below the fiduciary mark *C*.

The handle is now turned until the mercury level reaches point *C* and a reading taken on the coarse scale. If the reading is less than 1 mm Hg (the 1 mark on the left-hand scale), the handle is turned until the level reaches point *B*, and a more accurate reading then can be made on the fine micron scale (Fig. 3).

The handle is unscrewed and pulled down to its original position between tests so that the mercury level is below the cut-off point (D), and a new gas sample is admitted.

Acknowledgement

The assistance of Mr. Isadore Gepner in designing the metal parts, and the permission of the Manostat Corporation to publish this material, are gratefully acknowledged.



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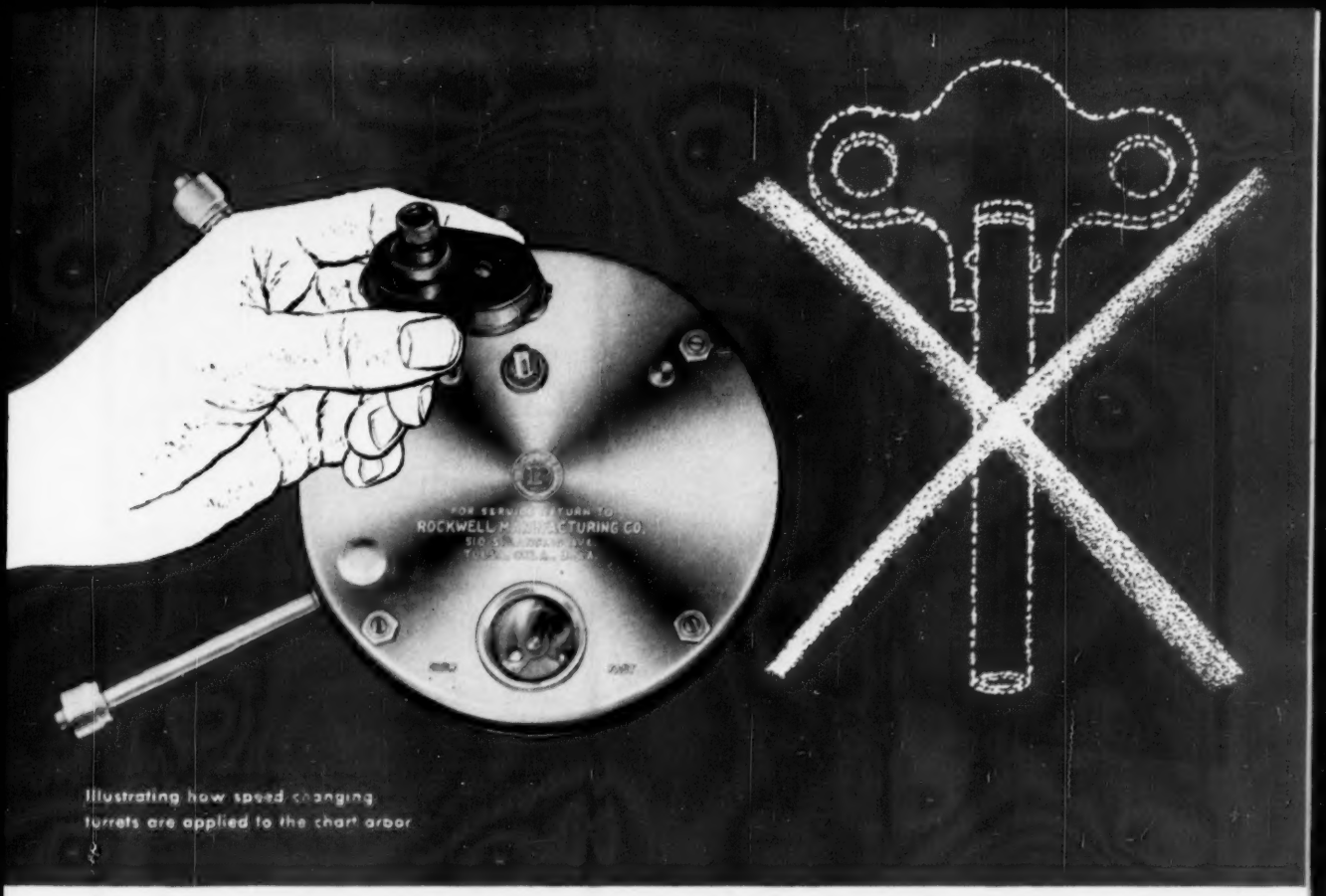

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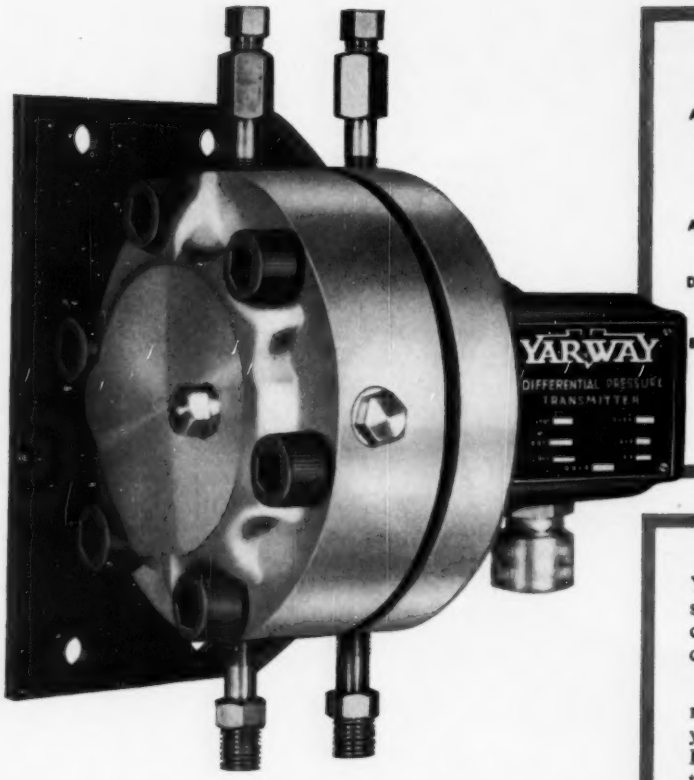

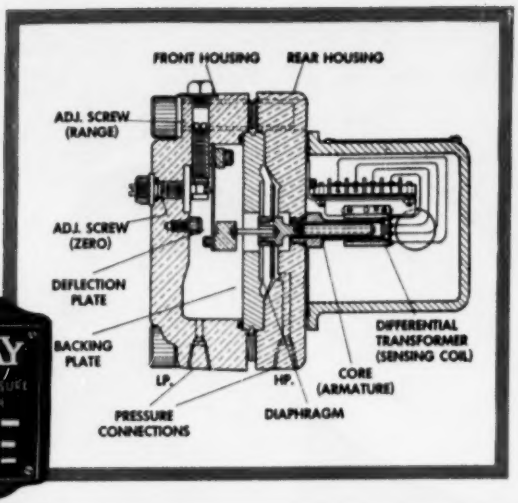

Yarway offers maximum simplicity in new DIFFERENTIAL PRESSURE TRANSMITTER

for fluid flow and liquid level measurement and control in power and process plants, including nuclear applications

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YARWAY now offers a unique Differential Pressure Transmitter to operate remote indicators, controllers or other electrically-activated receiving instruments.

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CHECK THESE ADVANTAGES

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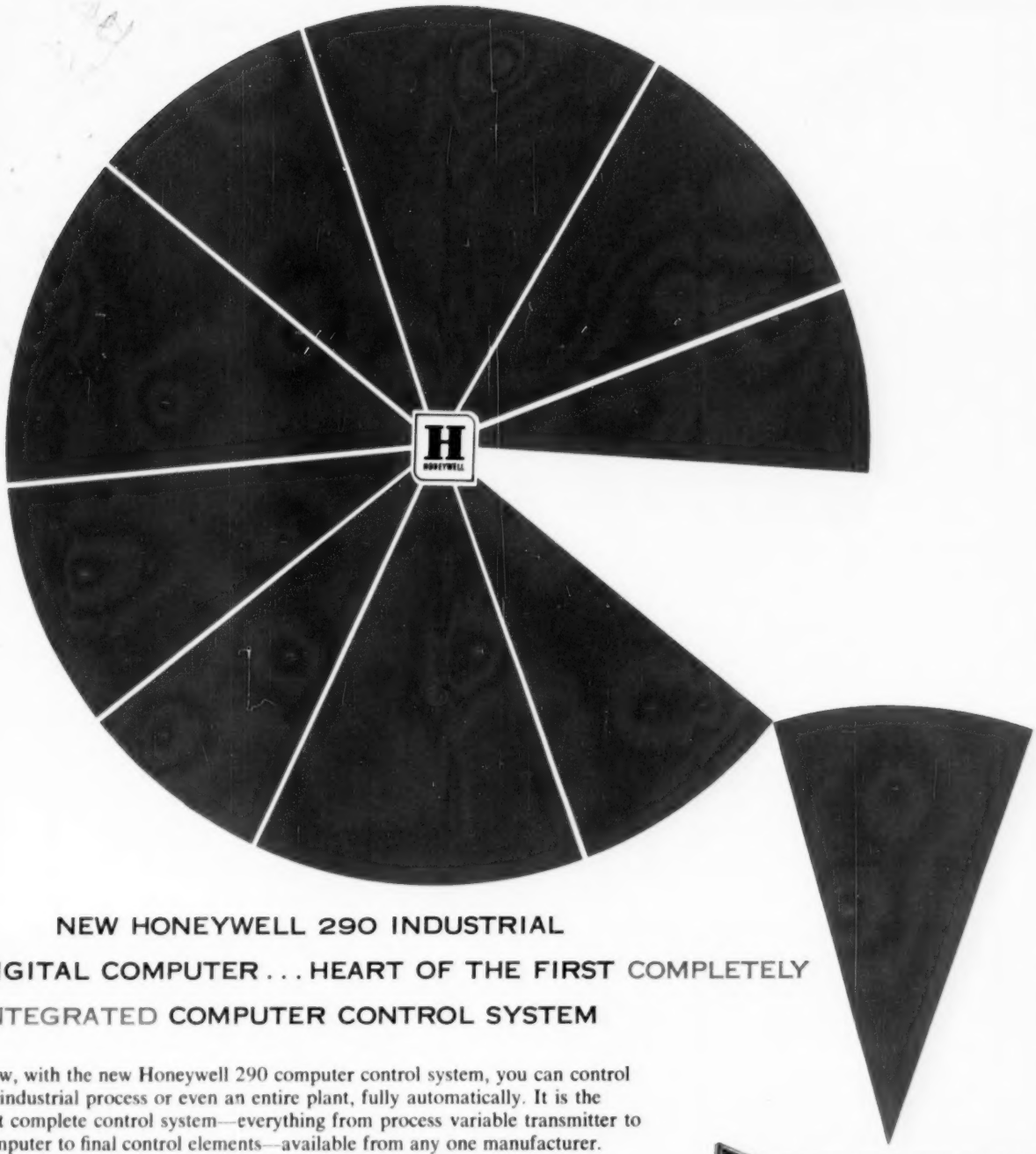
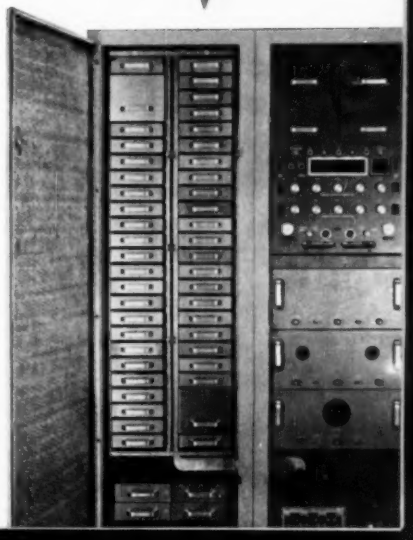


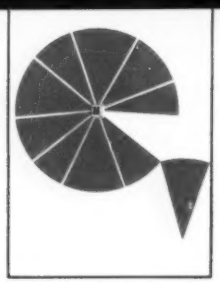
NEW HONEYWELL 290 INDUSTRIAL DIGITAL COMPUTER . . . HEART OF THE FIRST COMPLETELY INTEGRATED COMPUTER CONTROL SYSTEM

Now, with the new Honeywell 290 computer control system, you can control an industrial process or even an entire plant, fully automatically. It is the first complete control system—everything from process variable transmitter to computer to final control elements—available from any one manufacturer. Heart of the system is the new Honeywell 290 industrial digital computer.

The Honeywell 290 is the most powerful computer in its class, despite its small size, low cost and low power consumption. It performs, for example, 8,000 additions, 1,250 multiplications or 400 square root extractions per second. Unique, powerful macro-instructions help make the 290 easy to program, reduce working memory requirements and increase operating speeds. These special instructions augment the basic instructions, and eliminate many special subroutines.

The combination of high-speed operation and the reliability of conservative solid-state circuitry brings optimum control of many types of industrial processes. In addition, the Honeywell computer control system can compile complex operating guides, correlate data, and reduce huge masses of acquired data into immediately usable information for monitoring or optimizing process operations.





NEW HONEYWELL 290 INDUSTRIAL DIGITAL COMPUTER . . . HIGH SPEED, PARALLEL OPERATION, EASILY PROGRAMMED

The high computation speed of the Honeywell 290 provides many advantages in on-line monitoring and control of industrial processes:

- Higher sampling rates give closer control because each variable can be checked more frequently.
- More work can be accomplished in a given time.
- Checking and validity routines can be used extensively.
- Tasks other than process control can be accomplished either through time-sharing or through priority instructions in the computer program.

The Honeywell 290 is the first industrial digital computer to use parallel operation within the computer. All digits in a multi-digit number are transferred *simultaneously* from one element to another within the computer . . . in one count of the clock. Therefore a much slower clock rate can be used. Components are operated far below their maximum ratings—greatly increasing overall reliability, while permitting many thousands of program steps to be executed each second.

The computer combines both magnetic core and drum memory. Main memory is the magnetic core type, and it can be supplied with capacities of 1,024, 2,048 or 4,096 words. A magnetic drum memory with a capacity of either 4,096 or 8,192 words is also provided—a total capacity of 12,288 words. This combination gives you the speed and random accessibility of core memory with the program permanence of drum memory.

The Honeywell 290 Computer operates with standard, field-proved Honeywell process instrumentation in a completely integrated system of control. *ElectriK Tel-O-Set* transmitters feed process variable input data to the computer. These solid-state, two-wire transmitters convert temperature, pressure, flow and other measurements into electric signals. Various types of computer peripheral equipment are supplied by Honeywell to add flexibility to the system and make it easily expandable to meet future requirements. This equipment includes analog-to-digital and digital-to-analog converters, high-speed paper tape readers and punches, visual displays and electric typewriters. Honeywell *ElectriK Tel-O-Set* transducers make the computer completely compatible with existing pneumatic process measuring and control instruments.

Get complete details from your nearby Honeywell field engineer. Or write for Catalog C-290. MINNEAPOLIS-HONEYWELL, Wayne and Windrim Avenues, Philadelphia 44, Pa. In Canada, Honeywell Controls, Ltd., Toronto 17, Ontario.

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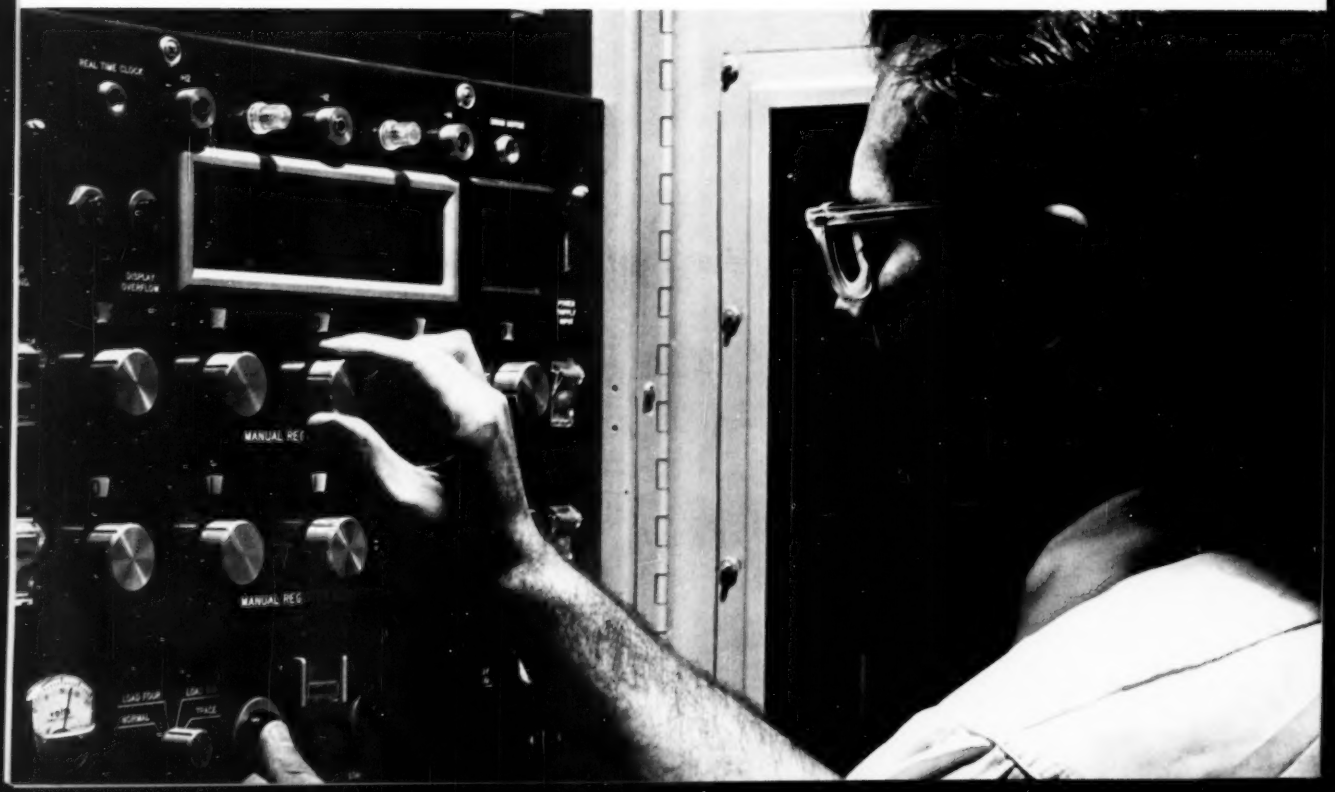
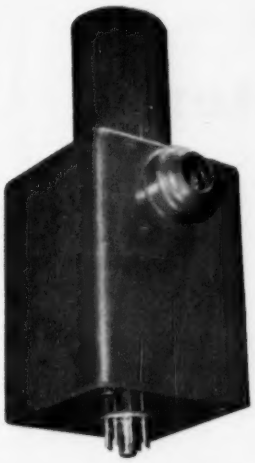


NEW

STATIC POWER AMPLIFIER MODULES

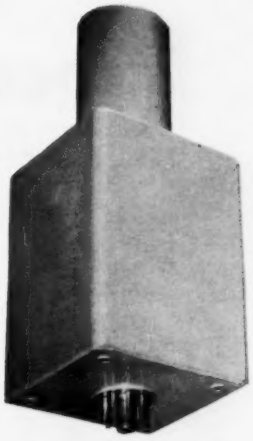


Photosensitive Module
Model 101 PC

The model 101 PC module is a self-contained, hermetically sealed, static device. It will switch power to the load on or off, in the presence or absence of light, as required, or give a proportional change of output with a corresponding light intensity change. Two units may be connected in a light bridge arrangement to give a servo output sensitive to magnitude and direction of light unbalance. In this manner, solenoids, heavy contactors or motors may be controlled directly without auxiliary circuitry. Since no contacts are utilized, arcing, pitting and wear are eliminated.

MAXIMUM RATINGS:

Photosensitivity (visible)	5800 angstroms
On-off repetition rate	10 pulses/sec.
Continuous voltage	440 v ac
Continuous average load current	1 ampere
Intermittent current	5 amperes
Fault current for .1 second	70 amperes
Peak instantaneous	1200 v



Control Module
Model 101 C

The model 101 C control module is a completely self-contained, hermetically sealed, static device. It will switch power on or off to its load or proportionately modulate the power applied to the load in accordance with the input command signal. Two units form a servo amplifier package whose power output is sensitive to both amplitude and direction of error. Control input is high impedance and may be fed directly from a transducer. This includes resistive, capacitive or inductive pickup devices.

MAXIMUM RATINGS:

Switching rate	60 cps synchronous
Continuous load voltage	440 v
Continuous average load current	1 amp
Intermittent or peak pulse current	5 amps
Peak recurrent current	8 amps
Peak voltage transients permissable	1250 v

The command signal requirements are −6 v to +6 v for 0 to 100% output. Control circuit impedance is 300,000 ohms.

Full load efficiency is 94%

TYPICAL APPLICATIONS:

Regulated or programmable power supplies
DC or AC servo amplifiers
Proportional temperature controllers
Contactless relays (10 micro second closure)

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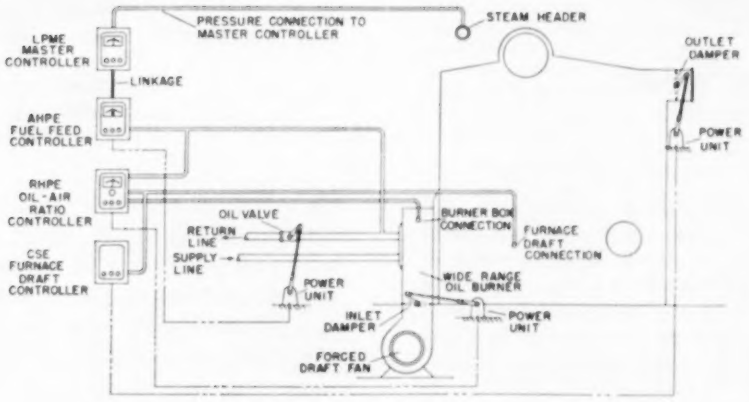
Process Control Systems

FRED D. MARTON, Instruments Publishing Company

COMBUSTION CONTROL FOR MEDIUM-SIZE OIL-FIRED STEAM PLANT



This all-electric metering system for combustion control of medium-size steam-producing plants (between 20,000 and 100,000 lb/hr steam output) comprises four controllers—the master steam pressure controller, a fuel feed pressure controller, an oil-air ratio controller, and a furnace draft controller.

The *master controller* responds to changes in the steam pressure in the header and adjusts the fuel feed controller (an adjustable pressure controller) by a linkage.

The *fuel feed controller* is adjusted for the required oil pressure in the return line from the burners. This controller operates an oil valve in the return line. As it is adjusted for the base minimum and maximum oil pressure it does not depend on the position of the oil valve alone for the control of the fuel.

The *oil-air ratio controller* also measures the return line oil pressure as a function of the quantity of oil being burned; is also measures the drop in pressure between the burner box and the furnace draft as a function of the quantity of air being used to burn the fuel. The controller operates the inlet damper at the forced-draft fan to maintain the proper relationship between the quantity of air and the quantity of oil. Burners can be cut in or out of service without requiring any manual adjustments to the control equipment.

The *furnace draft controller* measures the furnace draft and controls draft to a set point by controlling the boiler outlets damper through its power unit.

In order that manual operation from the control panel may be achieved, each controller is provided with a *manual control station*, consisting of a selector switch marked HAND or AUTOMATIC and two (manual) switches marked OPEN and CLOSED.

The Hays Electric Power Units, which operate both the inlet damper at the forced-draft fan and the boiler outlet damper, are equipped with hand-wheels which permit manual operation of the damper through a direct mechanical drive without de-energizing the controller or placing it on HAND operation.

Equipment used:

1. Master steam controller, Model LPME, with proportional action.
2. Fuel feed controller, Model AHPE, has single-speed floating action.
3. Oil/air ratio controller, Model RHPE, has proportional plus floating (reset) action.
4. Furnace draft controller, Model CSE, has proportional-speed floating action.

Source: The Hays Corp., Michigan City, Ind.; also "Results" Bulletin "Hays Combusion Control Attains High Efficiency at Sunshine Biscuits, Inc."

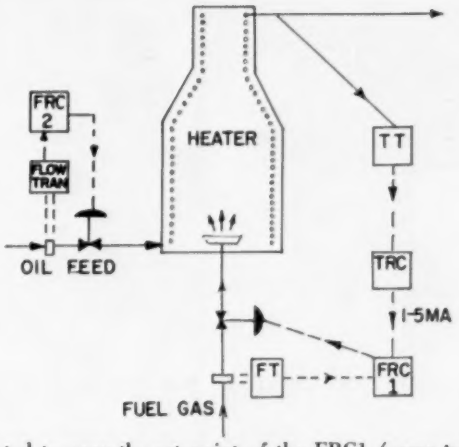
CASCADED CONTROL RESETS FUEL-GAS FLOW CONTROLLER TO KEEP DISTILLATION-TOWER FEED AT CONSTANT TEMPERATURE

Feed to a distillation tower must be held at a constant temperature to insure a uniform end product. Thus the fuel gas to the heater must be controlled to maintain the desired heat supply. This control action would be easy if the fuel gas pressure could be held constant throughout the refinery. However, changes in demand causes gas pressure changes which show up as temperature changes only after considerable delay.

This cascade control system uses a temperature controller (TRC) to reset the control point of a fuel flow controller (FRC1). The latter maintains a steady, controlled flow of fuel as long as the temperature controller maintains a steady temperature at the outlet.

The oil-feed flow rate is held constant by another controller, FRC2. Thus temperature changes in the hot feed will be small and can be caused only by some load change in the system, such as changes in excess air in the furnace.

Equipment used: The temperature transmitter is an electronic Type E700 Microsen with an output signal of 1 to 5 ma. The temperature recorder controller (TRC) is Type C120 (indicating) or Type C110 (recording). Its output is combined in the flow controller (FRC1) with the signal received from a Type 154W differential-pressure transmitter, which measures the flow or fuel gas. The two signals can be added or subtracted to vary the set point of the FRC1 (same type as the TRC—Type C120). Mode of control in both instruments is proportional, rate and reset. The output from the FRC1 positions the stem of the fuel control valve, which is equipped with a Type 132 valve positioner. The large size valve is double-seated for easier balancing.



Source: Robertshaw-Fulton Controls Co., Aeronautical, and Instrument Div., Anaheim, Calif.

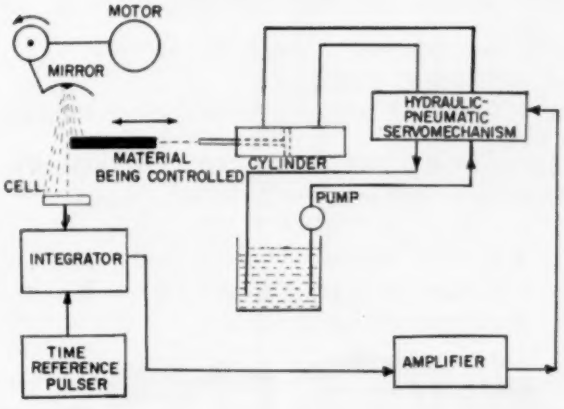
EDGE GUIDE CONTROL BY PHOTO EYE

Where it is not possible to have a mechanical device feel the edge position of moving material, a non-contacting light beam gives an inexpensive yet efficient solution to the problem.

A timing motor moves a shutter or mirror so that a modulated light beam strikes the photoelectric cell, which sends a signal into an integrator. The intensity depends on the edge position to be controlled. The signal is compared with a constant chopper signal produced by a time reference pulser. The output signal from the integrator is amplified and used to position a hydraulic servo valve. This valve positions a master cylinder which controls the edge position.

Instrumentation: Motor and optical system; Integrator; Time Reference Pulser; ATC Amplifier; ATC hydraulic or pneumatic servomechanism (servo valve) plus cylinder.

Source: Automatic Timing & Controls, Inc., King of Prussia, Penna.; also Laboratory Report AELR 17.



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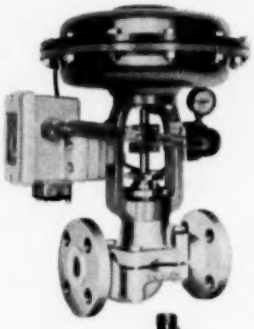

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- *Pressures to 150 p.s.i.g.*
- *Temperatures to 450 F.*
- *Cv .01 to 1000 and higher.*
- *Suitable for slurries, corrosives, etc.*
- *Valve positioners, direct and reverse acting.*

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- *Steel, S. S., Hast "C", Monel, Aluminum, etc.*
- *Pressures to 15,000 p.s.i.*
- *Bellows Seal Valves—Interchangeable seats and plugs.*
- *Cv range .00001 to 6.5*
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  Air to close, spring to open in sizes to 2"

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In maintaining its tradition of quality, Teletype's manufacturing methods play a major role. Specialized machine tools, like the jig grinder shown above, selective heat-treating processes, electronic measuring devices—these are part of a manufacturing technique that insures consistent quality.

When you select Teletype equipment, you can be sure of dependable, trouble-free performance. Teletype Corporation manufactures this equipment for the Bell System and others who require the utmost reliability from their data communications systems.

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APPLICATION OF CHROMATOGRAPHY

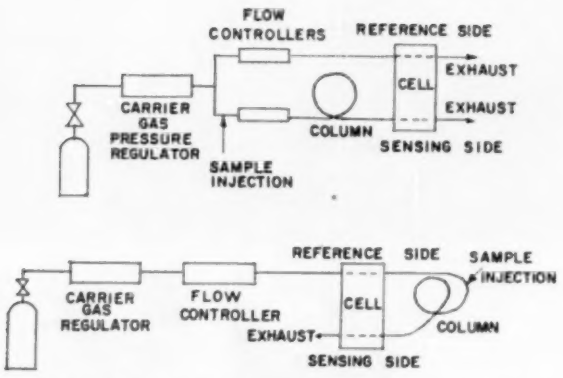


FIG. 1. SPLIT FLOW arrangement is shown at top. Single flow line is shown at bottom.

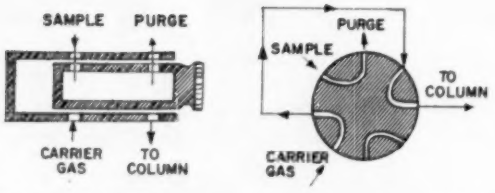


FIG. 2. SAMPLE is caught in tube when tube is rotated. One-half turn then turns port down, admitting carrier gas, and the sample is carried to the column. Bottom shows an alternative design, a rotatable piston which traps sample and places it in column stream when rotated 90°.

CHROMATOGRAPHY was developed as a science early in the 20th century when it was discovered that materials passed through an inert medium of high absorptive capacity change in composition as they pass through the medium. Michael Tswett, a botanist, used this technique for separation of the highly-colored plant pigments, carotene, chlorophyll, and xanthophyll. Separation was controlled by observing the vivid color changes, thus the name chromatography comes from the Greek word "chroma" which means color.

Although this technique is still in use today for such tasks as separation of rare-earth metals and purification of antibiotic compounds, the practical application of liquid and gas adsorption chromatography as we know it today differs somewhat from the earlier technique. In the post world war II period in England, much attention was directed to the study of passing gases over stationary solid adsorbents, or inert solids coated with high-boiling liquids as a stationary phase, and an inactive carrier gas along with the sample as the phase in motion. It was found that, by selective adsorption, components with even small differences in boiling points, molecular weights, or composition could be separated readily.

It soon became apparent that a new and powerful aide was now possible for laboratory analytical work, and so many manufacturers developed the instruments which are now known as chromatographs. They are used in addition to such well-established methods as fractional distillation and chemical and physical separation.

Presented at 9th annual Instrument Short Course, Southern California Meter Association, Los Angeles Harbor Junior College, April 13, 1960.

E. L. ERICKSON, Mobil Oil Company

TO NATURAL-GAS ANALYSIS

Gas chromatography is used as an analytical technique for the separation, identification, and quantitative determination of gases and liquids having boiling points up to 350-400°C. All of the chromatographic techniques employ the transportation of a sample through a column where the individual components are separated one from another.

Natural-Gas Analysis

Chromatographs in use today employ a technique which is known as *elution* analysis. By this method, a sample is introduced into a continuous and constant stream of carrier gas which moves the components through a column at different speeds. This speed varies with each component because of the difference in adsorption on the surface of the packing within the column. The advantages of this method of analysis are that the column is continuously regenerated by the carrier gas and that the components can be separated one from another although they are mixed with the carrier gas.

Component parts of the instrument include: a sample injector, or a device for introducing the sample into the instrument, a column which separates the components so that they can be measured, and a detector for measuring each component separated.

All other components of the instrument are incorporated for the control of the three variables which will affect the sensitivity of the instrument: (1) pressure, (2) flow rate, and (3) temperature.

Various manufacturers will incorporate the component parts differently, but essentially all chromatographs are made quite similarly. Two types of flow charts are shown in Fig. 1 to show different methods of operation.

It is possible to incorporate further modifications to these methods of operation, such as dual columns, back-flushing equipment, split-column operations, etc.; but these are merely variations.

Almost any of the inert gases can be used as the carrier gas. Measurement of the components through the cell is accomplished most often by thermal conductivity—by the difference in the conductivity of the carrier gas to that of the components. Thus, the greatest difference would give the maximum sensitivity of the instrument. Table 1 lists thermal-conductivity ratios of various gases at 0°C, with isopentane equal to 1.00.

Hydrogen is the ideal gas to use, but it is dangerous because of its explosive qualities. Therefore, helium is almost universally used as the carrier gas for reasons of safety. It is inert, relatively inexpensive, and offers good instrument sensitivity. At the present time, helium is highly in demand for defense purposes, so its availability in the future, is somewhat questionable. Neon would be the next most desirable gas to use. Nitrogen has been used, but not in the natural-gas industry.

Vapor-injection systems use a hypodermic syringe or some means whereby a segment of a sample

TABLE 1—THERMAL CONDUCTIVITY RATIOS

Component	T. C. Ratio	Component	T. C. Ratio
Hydrogen	13.61	Methane	2.47
Helium	11.55	Oxygen	1.96
Neon	3.74	Nitrogen	1.95
Argon	1.33	Air	1.91
Carbon Dioxide	1.16	Ethane	1.48

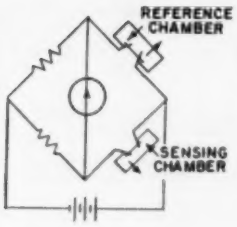


FIG. 3. CELL forms part of a Wheatstone bridge. Only carrier gas passes through reference chamber, while carrier and sample pass through sensing chamber.

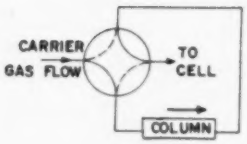


FIG. 4. BACK-FLUSH valve reverses flow through column when it is rotated 90°.

purge line may be inserted into the column flow line where it will be swept away by the carrier gas (Fig. 2). Only vapor samples can be injected in this manner. It is not necessary to know the exact volume of sample gas (although it is generally determined for calibration purposes) as long as the sample volume is reproducible. A separate injection system usually is provided for liquid samples.

Component Identification

Identification of components is accomplished by what is known as retention time. This is the elapsed time from sample injection to when the component elutes from the column to the cell. Under constant conditions of flow rate and temperature, the retention time for any particular component on any particular, single column will always remain the same. Thus, it is necessary only to compare any peak retention time with that of a pure component which has been determined previously.

Calculation of component percentages is accomplished by measuring peak height or, better, peak area (the area under the component peaks), corrected for differences in component response. Most chromatographs are now equipped with integrators to measure area automatically. This enables the operator to eliminate the time-consuming task of measuring area with a planimeter.

Measurement of component response is accomplished most often by means of a thermal conductivity cell. This cell is made up of a thermally insulated block with detector elements of thermistor beads or hot tungsten filaments. The filaments are heated electrically and their temperature held constant. If the cell block is held at a lower temperature, heat will flow to it from the filament. The rate at which this heat flows is proportional to the thermal conductivity of the gas surrounding the filaments. If the filaments are arranged so as to form the two sides of a Wheatstone bridge (with the reference filament as one side and the sensing filament as the other side) any change in thermal conductivity supplied by a change in gas medium will provide an imbalance to the bridge (Fig. 3). It is necessary to measure this imbalance on a millivolt meter or transpose this signal to a millivolt recorder. The imbalance mentioned is caused by a voltage change when the filament resistance is altered by a rise or fall in filament temperature.

When no component is passing through the sensing side of the cell, only the carrier gas is present in both sides. The recorder is balanced to zero. When a mixture of the carrier gas and a component is passing through the sensing side, the recorder indicates its presence by the peak on the chromatogram. After the component passes through the cell, the recorder returns to its baseline response to await the next component.

Columns

Chromatographic columns used in natural gas analysis are of three different types:

1. *Molecular Sieves*—Synthetic zeolytes separate components by differences in molecular size. They are valuable for separation of hydrogen, oxygen, nitrogen, and methane from the sample mixture. Carbon dioxide is not eluted in this case, nor is any acid gas.

2. *Solid Adsorbents*—Silica Gel or Alumina separate components by selective adsorption; i.e., freeing first one component and then another as the sample passes through the column. They are valuable for separation of air (they will not split oxygen and nitrogen from air), methane, ethane, and carbon dioxide from the sample mixture.

3. *Liquid-Solid*—These general purpose columns use an inert solid (such as crushed firebrick) coated with a high-boiling liquid (such as silicone and apiezon greases, tri-cresyl phosphate, etc.). These columns separate components by adsorption of the component in the liquid phase, then freeing the component by differences in vapor pressure or boiling point. The fixed gases (such as ethane and carbon dioxide) are not eluted completely as separate components, but the propane and heavier components elute quite satisfactorily.

Since most natural gases contain predominantly parafinic material, a combination run through all three columns listed above will give a complete and accurate analysis. If any non-parafinic compounds are present, further runs on special columns are necessary to determine their presence.

Controls

Instrument controls listed below are primarily for stability purposes.

1. *Voltage Control*—If an a-c current is used, a voltage control device can eliminate power bumps in line currents. If a d-c current is used, a current stabilizer is used.

2. *Flow Control*—Either orifice restrictions with pressure regulators, or constant-flow regulators

with manometers or flowrators are used.

3. *Temperature Control*—On-off relay switches or full-proportional heater circuits are provided. Some chromatographs are made with the column and cell in one thermal compartment, others have separate compartments for each.

4. *Attenuator or Sensitivity Switches*—A nominal 1 milliliter sample volume will produce approximately 100 millivolts or more on most chromatographs. Therefore, at maximum sensitivity of the instrument, the peak height would appear far beyond the limit of the 1-millivolt recorder. Sensitivity switches are provided to attenuate this peak height in steps usually of 1/2, 1/5, 1/10, 1/20, 1/50, 1/100, and 1/200 of peak height at maximum sensitivity. Attenuation permits operation at great sensitivity without sacrificing analysis of large percentage components.

5. Polarity switches are provided with some instruments so that reference and sensing sides of the cell may be reversed.

Reading the chromatogram is made much easier if these controls are accurate. The portion of the chart between peaks (where no signal is indicated) is known as the baseline. High stability is mandatory to provide minimum baseline drift.

Sensitivity and Uses

Early chromatographs used a 10-millivolt recorder, but trace components were not detected. Now most instruments are equipped with a 1-millivolt recorder—trace components as slight as 1 part in 100,000 are now detected satisfactorily.

Chromatographs can be used for samples that can be completely vaporized, such as dry gases, propane, iso and normal butanes, and LPG. They also can be used for samples that can be injected in a liquid state, provided the boiling range and vapor pressure are not too high.

At present, chromatographs cannot be used for samples that are in a combination vapor and liquid state, such as high-vapor-pressure natural gasolines. The reason is that there is no satisfactory method of introducing the sample in its homogeneous form into the chromatograph. When vapor samples are injected, the sample is purged through a line to the chromatograph, then the sample-bomb valve is shut off to allow the purge line to adjust its pressure to atmospheric. This cannot be done with vapor-liquid samples, because the sample would have to be injected by hypodermic syringe; the light hydrocarbons and fixed gases would vaporize, and the remaining liquid sample would not be of the correct composition.

New Techniques

The use of multiple-column operations by ingenious plumbing modifications enabling two or three columns to be in standby use in the thermal compartment without the formality of changing columns each time a different type of analysis is desired, has greatly increased the efficiency of the operator's running time.

Also, the use of back-flushing or reverse-flow valves has increased running time efficiency for heavier components. A typical back-flush valve is shown in Fig. 4; a turn of 90° either way will reverse the flow through the column:

The back-flushing running time is approximately equal to the pre-back-flush period, or time from sample injection to back-flush initiation. Plumbing modifications make it possible to route this back-flush portion through the conductivity cell so it can be measured as a part of the chromatogram. However, there is some difficulty at the present time in interpreting correctly the back-flush portion of the chromatogram. Analysis of wet gases and low-pressure gasolines can not, as yet, be accurately run on the chromatograph by back-flush methods.

A new technique being evolved is analysis by straight-through (not back-flush) running of a sample with temperature programming. In this case, the run is started at low temperature (ambient) and gradually increased throughout the run until a final temperature of about 300°F is reached. This has the effect of decreasing running time for the heavier components. The column must be in a thermal compartment separate from the cell, as the temperature of the gas entering the cell can not change without affecting component area response. It is necessary to cool the hot vapors eluting from the column to the cell inlet temperature prevailing at the start of the run.

Still another technique is analysis with small-bore capillary columns which contain no packing, but are coated with high-boiling liquids.

New instruments are on the market for specialized analysis of natural-gas components. Among these are infrared analyzers, flame ionization detectors, mass spectrometers, beta-ray ionization detectors, and many others; yet, none of these has been as universally accepted as chromatographs for practical, general-purpose use in industry.

S. C. M. A. HANDBOOK

SECTION INDEX

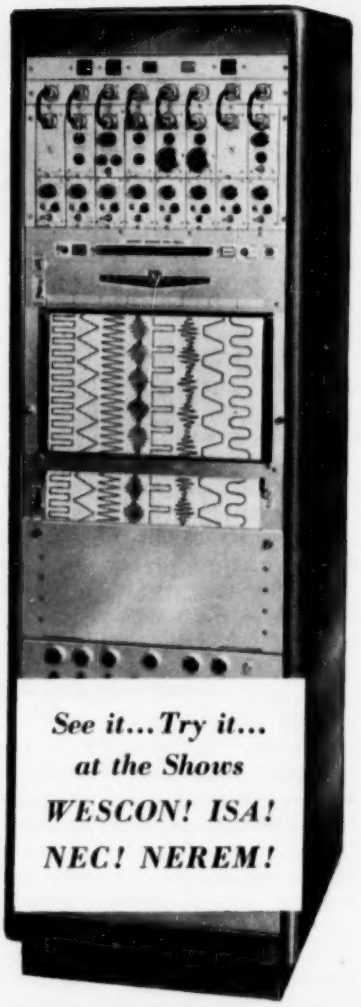
Title	Section	Title	Section
Gas Flow—General	1	Flange and Piping Data	8
Gas Flow—Flange Taps	2	Boiler and Power Data	9
Gas Flow—Pipe Taps	3	General Flow	10
Steam Flow	4	Conversion Tables	11
Liquid Flow	5	Physical Contents	12
Displacement Meters	6	Temperature Tables	13
Square Root Chart Data	7	Miscellaneous	14

MEETING NOTICE

September Meeting: Thursday, September 15, Rio Hondo Country Club, Downey, Calif.

Feature: Panel Discussion on "Control of Distillation Columns," by E. L. Peatross (chairman), Taylor Instrument Companies; J. F. Berkman, Standard Oil Company; E. H. Reynolds, Richfield Oil Company; A.M. Whistler, Fluor Corporation, Ltd.

Here's why the NEW AO TRACE-MASTER is the world's finest 8-channel direct writing recorder!



American Optical Company, famous for precision instrumentation for 138 years, introduces an electronic direct-writing recorder of unique design, in which ultra-precise electromechanics has been combined with advanced electronics to achieve *truly superior performance.*

Finest Writing Method Ever

Unique direct-carbon-transfer writing method. Trace is uniformly black and up to four times thinner than that made by any other recorder. Minute variations in phenomena measured are more faithful, meaningful. Carbon trace cannot fade... may be easily reproduced.

Finest Frequency-Amplitude Performance

TRACE-MASTER'S multiple-feedback wide-range Driver circuitry, combined with the advanced pen-motor design, produces wider frequency response *at larger amplitudes* than any other recorder. TRACE-MASTER response is flat—*within 1%*—from dc to 110 cps at 40 mm!

Band Amplitude Product (i.e. Bandwidth times Amplitude) is 5600...140 cps (3 db point) x 40mm!

Finest Chart-Drive Facilities

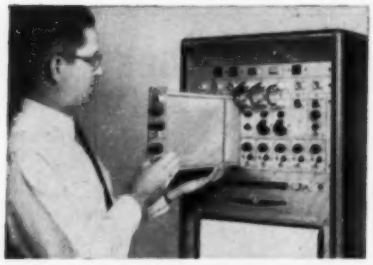
TRACE-MASTER provides widest chart-speed range...0.1 to 500 mm/sec...of any direct-writing recorder! Convenient push-button selection. Take-up reel automatically stores full 1000 ft. record. Writing table tilts for easy chart annotations. Guide rails permit quick, easy paper-roll changes. Low cost chart paper makes practical protracted recording at high speeds.

Finest Resolution, Linearity, Stability

Thin carbon trace (thinner by 4 to 1 over most recorders) and high Band Amplitude Product (higher by 6 to 1 over other recorders) provide up to 24 times the resolving power or ability to detect short, sharp variations in the record. The superior linearity (± 1%) and stability in rectilinear presentation permit full use of this unexcelled resolution.

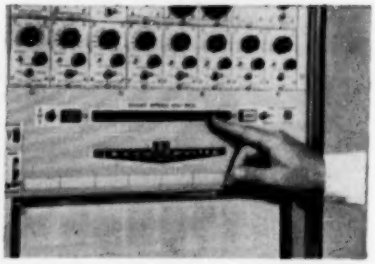
Finest Systems Oriented Compatability

Fully transistorized circuitry...application of combined dc level and signal multiple feedback...complete interchangeability of modular signal-conditioning elements... are some of the features that make the AO TRACE-MASTER the world's finest 8-channel direct writing recorder.



Entire channel easily accessible and completely interchangeable as single unit.

Platen tilts to convenient writing angle.



Widest range chart speed . . . push-button selection through 0.1 mm/sec to 500 mm/sec.

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because the Tenney 3 environmental test chamber will move, in that length of time, from ambient to either −40°F or +200°F. And extremes of −120°F and 350°F take just a little longer. There are also variations of the T-3 to meet every temperature and load dissipation need, every budget. Humidity environment is available as a standard option. All have cascade refrigeration system; single electrical connection. Perfect for testing electronic components, instruments, military qualification specs, and for metal aging, shrink fitting, tool chilling, liquid baths, preservation of pharmaceuticals, and hundreds of other testing and production jobs. For more information on the T-3 and other units, write today to:

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PLANTS: UNION, N. J. AND WILMINGTON, N. C.

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What!!

a universal counter-timer with in-line NIXIE readout

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Yes, sir! It's true. And the new Erie Model 725 has all the quality features usually found in instruments costing up to 50% more.

Model 725

Model 725 accurately counts cyclic or random electrical events and precisely measures frequency, period and time intervals. NIXIE readout is available in 5 or 6 decades. Major components are independent modules for easy maintenance. An internal SELF-TEST automatically checks counter operation.

Incorporating quality, flexibility, performance and PRICE, the Model 725 is your best instrument for production or laboratory use. Why not send for complete technical literature today?

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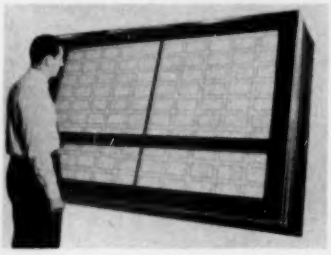
CIRCLE 100 ON READER-SERVICE CARD

IGS NEW INSTRUMENTS

Scheduled for Display at ISA Show

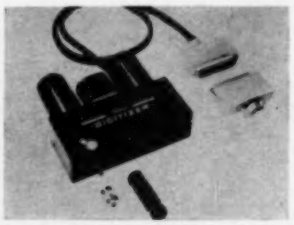
400-POINT RECORDER



New K-Logger, a new type of Multiple Recorder and Annunciator, records and displays on one chart all the variables in even the most complex of processes, and is a miniature graphic panel in its own right. It makes from 10 to 400 analog recordings, at rates up to 10 points/sec in 4" x 6" chart frames printed in columns and rows on one large sheet of paper. The chart is held against a translucent platen, or printing surface. Transparent process symbols cut from colored plastic film are applied to the platen and show through the chart to form a graphic panel with full color-coding. Annunciator alarm lights are mounted immediately behind the appropriate chart frames and high-intensity light spots signify alarm conditions.—*Keinath Instrument Co., 1223 Grandview Ave., Columbus, Ohio.*

CIRCLE 251 ON READER-SERVICE CARD

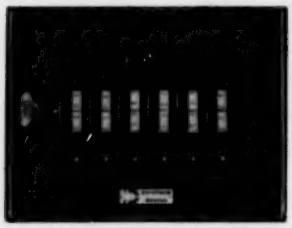
SHAFT POSITION ENCODER



New Decimal Digitizer, a nonambiguous electromechanical Shaft Position Encoder, provides straight decimal contact closure output. Features include continuous or on-demand readout, slewing speeds up to 3000 cts/sec, 5 sections of resolution ranging from 10 to 1000 cts/rev, high current carrying capacity, low input torque, parallel-entry operation of printers, and direct operation of lampbanks. Units available in 3, 4, 5, and 6 decades.—*Coleman Electronics, Inc., Gardena, Calif.*

CIRCLE 252 ON READER-SERVICE CARD

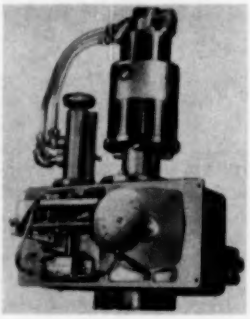
MULTIPOINT CONTROLLER



New Model 6134 is a Multipoint, non-indicating Controller with electric contact control. It combines 2, 3, 4, 5, or 6 individual measuring circuits and control circuits in one instrument with a common amplifier. Incorporating a unique stepping and memory circuit, the controller periodically samples each measured variable and the related control setting and takes the proper control action to compensate for any deviation of the measured variable from the set point. Two position or three position control is available as well as differential gap control.—*Weston Instruments Div., Daystrom, Inc., 614 Frelinghuysen Ave., Newark 12, N. J.*

CIRCLE 253 ON READER-SERVICE CARD

PNEUMATIC PUMP CONTROLLER



New Pneumatic Controller responds to an air signal from a W&T Merchen gravimetric feeder varied by the flow rate of dry solids through the feeder. Requiring only 21" headroom, it bolts onto any run-adjust model of W&T Series 200, 400, or 600 pump, in place of the normal adjusting handle. The controller accepts either linear, square root or other exponential signals, making it flexible in use.—*Wallace & Tiernan Inc., 25 Main St., Belleville 9, N. J.*

CIRCLE 254 ON READER-SERVICE CARD

FOR FURTHER INFORMATION USE CARD ON PAGE 1437

LAB VISCOMETER

New Laboratory Viscometer utilizes the principle of measuring pressure drop through a capillary. Designed by Shell Development Co. for use in the petroleum laboratory, it permits the measurement of many samples of petroleum products and obtains a record on a chart for each sample. Unit consists of a temperature-controlled constant-temperature bath containing a heat exchanger coil and a metering pump. The metering pump takes the sample and pumps it through the heat exchanger, discharging it to the entrance of the capillary, which in turn discharges the sample to atmosphere.—*Hallikainen Instruments,* 1341 *Seventh St., Berkeley* 10, *Calif.*

CIRCLE 255 ON READER-SERVICE CARD

ALARM ROTAMETERS

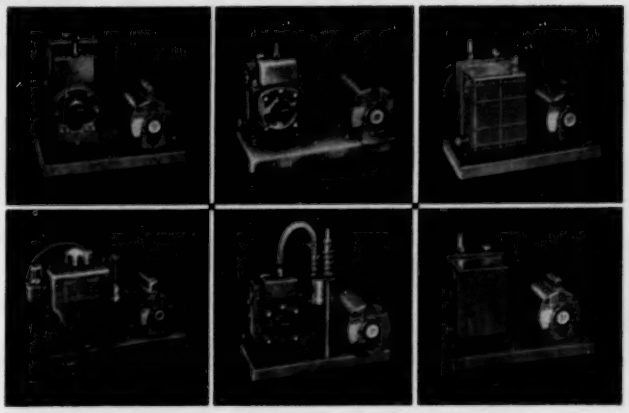
Two new types of Alarm Rotameters accurately measure fluid rates of flow, warning of abnormal flow rates, and start or stop a pump, motor, or control unit. (1) A typical Magnetic Alarm Rotameter (as illustrated) uses a float extension rod with an encapsulated magnet. (2) The Electronic Alarm Rotameter (not shown) employs a standard rotameter and a high-frequency pick-up sensing coil mounted flush against the metering tube. The coil is adjustable over the full range of the scale and is connected by cable to the electronic alarm.—*Schutte and Koerting Co., Instrument Div., Cornwells Heights, Bucks County, Penna.*

CIRCLE 256 ON READER-SERVICE CARD

QUIET - VIBRATIONLESS - ALL-PURPOSE

WELCH

DUO-SEAL VACUUM PUMPS



They are best because: Every pump is triple tested.
Specified performance guaranteed.
Lowest cost per year of use.
Highest vacuum of any mechanical pump.
Quietest mechanical pump made.

When you buy a Duo-Seal Vacuum Pump, you are buying a pump with a reputation. Over the years Duo-Seal pumps have built up this reputation for long-life dependability, quiet operation, long-term adherence to original specifications.

Rigid design requirements make these pumps quiet operating, long wearing; meticulous factory inspection methods make sure that every pump is perfect when it leaves the plant. Triple testing with McLeod gauges leaves no room for question on final performance.

The superior performance of Duo-Seal Vacuum Pumps is due in part to the use of Duo-Seal Oil, a specially processed product that maintains these pumps at highest vacuum and efficiency. Chemically stable, with low vapor pressure, Duo-Seal Oil meets the most rigorous laboratory tests. Oil .90 qt.

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IT'S WHAT'S INSIDE THAT COUNTS!

And a look inside **General Electric's potentiometric recorder** reveals how you get continuous, more reliable recordings of your process variables. Compare these important features:

1. SILICON DIODE REFERENCE VOLTAGE SOURCE

featuring plug-in design, provides continuous standardization - - and no dry cells or standard cells are required.

2. Multi-point Selector Switch

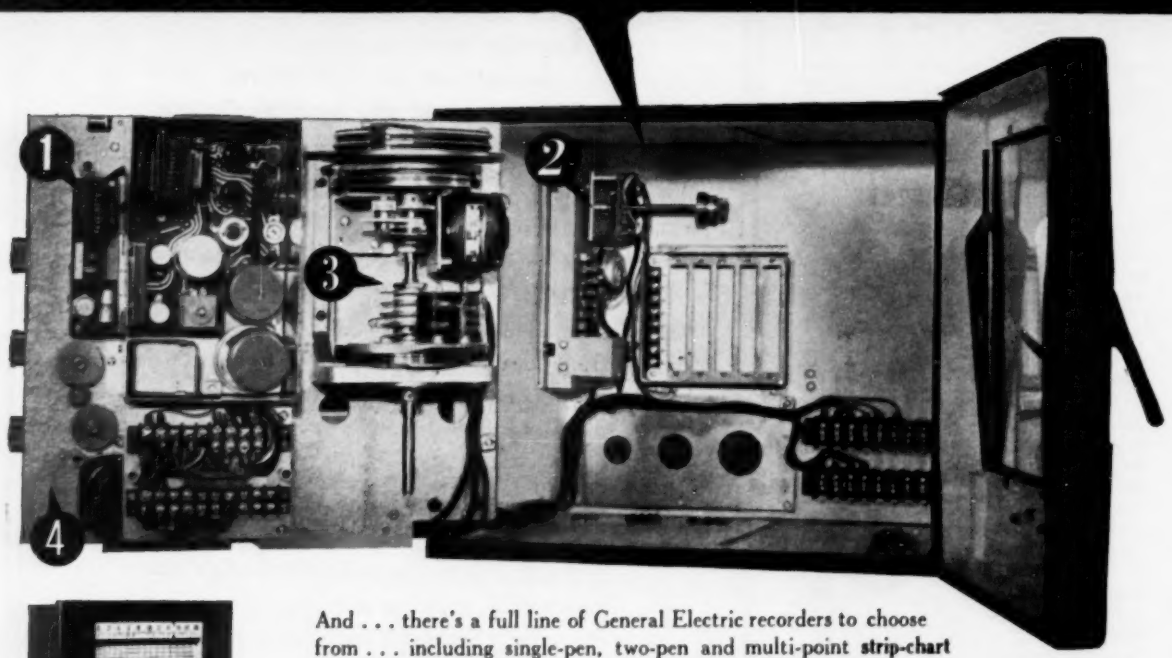
permits remote location - - eliminates long runs and multiple leads.

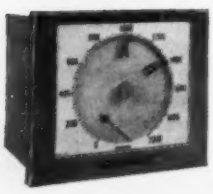
3. CONTROL SWITCHES AND SLIDEWIRES

easily accommodated - - up to 8 control or alarm switches - - up to 4 transmitting slidewires. As many as 4 switches may be adjusted by front-set index - - all switch positions independently adjustable.

4. COMPONENTS MOUNTED ON SWING-OUT PANEL

for easy accessibility include: plug-in amplifier, reference voltage unit, chart-drive motor and other measurement components.





And . . . there's a full line of General Electric recorders to choose from . . . including single-pen, two-pen and multi-point **strip-chart recorders;** plus single-pen and two-pen **round-chart recorders.**
Get the complete story on any of these recorders by contacting your nearest G-E Apparatus Sales Office today; or write for bulletins GEA-6887 and GEZ-2969, Section 599-04, General Electric Co., Schenectady 5, N. Y. In Canada, contact Canadian General Electric Co., Limited, 940 Lansdowne Avenue, Toronto 4, Ontario.

INSTRUMENT DEPARTMENT

GENERAL ELECTRIC

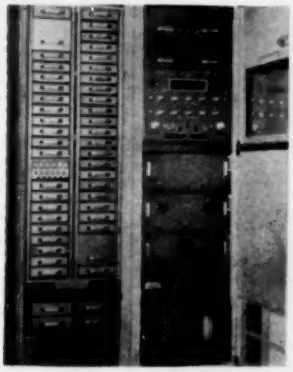
CIRCLE 102 ON READER-SERVICE CARD

MACHINE TOOL CONTROL SYSTEMS

New automatic Control Systems with numerical tape or automatic tracer control are said to be capable of automating virtually any machine operation in either large or small manufacturing plants. They include (1) the new Numerical Control System designed to control any three-axis machine used in turning, milling, punching, drilling, slotting, or routine operations; (2) the Multi-Mode Tracer Control, described as the most versatile system of its type ever developed, and usable on any machine that does contouring or die sinking; (3) Hydraulic Press Control, described as the first control system to allow the operator to automatically program the rate and position of the hydraulic ram of a large press from a control console; and (4) Tracer Controls for Lathes which make it possible to automatically machine any contour on a lathe—including turning squares on a lathe—without changing cutting tools. Picture shows control console for the Numerical Control System.—*Minneapolis-Honeywell, Machine Controls Div., 2747 Fourth Ave. South, Minneapolis 8, Minn.*

CIRCLE 257 ON READER-SERVICE CARD

TOTAL COMPUTER CONTROL SYSTEM



New completely-integrated Computer Control System for large-scale industrial processes is centered around the Honeywell 290 digital computer, a general-purpose all-solid-state device, designed for a broad range of industrial applications such as electric power generation, pipeline transmission of natural gas, petroleum refining, chemical and cement manufacturing, and steel mill rolling and strip operations. The computer features high-speed internal operation, magnetic core, and auxiliary magnetic drum memory, random access of input and output channels, and special instruction vocabulary. Typical operating rates of the computer are 8,000 additions or subtractions, 1,250 multiplications, or 400 square root extractions per second including memory access time. Both binary and decimal arithmetic are used by the computer. Other features include: single address, 18-bit word length consisting of a 6-bit operation code and a 12-bit address. Bulletin C-290 gives details.—*Minneapolis-Honeywell Regulator Co., Industrial Div., Wayne & Windrim Aves., Phila. 44, Pa.*

CIRCLE 258 ON READER-SERVICE CARD

SOLID-STATE TRANSDUCER

New Model PG313-5M-70, Serial Number 12, called the first "finished" Solid-state Transducer, is claimed to have thermal characteristics equivalent to the standard tolerances of strain gage devices, i. e. the thermal coefficient of sensitivity is in the order of 0.015%/°F and the thermal zero shift is less than 0.01% full scale per °F. Although the technical problems of performance have been solved, the manufacturing costs are relatively high and the solid-state transducer is not yet in production or available for immediate delivery. Information regarding the commercial availability of these unit will be released in the very near future.—*Statham Instruments, Inc., 12401 West Olympic Blvd., Los Angeles 64, Calif.*

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to visit the General Electric Instrument exhibit at the ISA show in New York, Sept. 26-30, Booth 1116-1126.

You'll see our . . .

NEW Industrial Mass Flowmeter and latest accessories for information handling in mass flow measurement.

NEW full-line null-balance Recorders for many applications, featuring latest two-pen round-chart recorder.

NEW semi-automatic leak test station for use with M-60 mass spectrometer leak detector. See our full line of halogen type leak detectors.

NEW electroluminescent 4 1/2 inch BIG LOOK panel meters and full-family panel meters.

NEW CF-8 "hook-on" watt-var recorder for utilities features quick, easy power factor determination.

NEW time meter featuring BIG LOOK appearance for matchup with G-E panel meters.

NEW low-cost AB-30 switchboard instrument featuring 1% accuracy and interchangeable scales . . . Make it a point to see how these new instruments, plus our many other quality-proved instruments, meet your applications and improve your profit picture. General Electric Instruments—the last word in measurement . . . the first in automation! 599-06

General Electric Co., Schenectady 5, New York.

INSTRUMENT DEPARTMENT

GENERAL ELECTRIC

CIRCLE 102 ON READER-SERVICE CARD

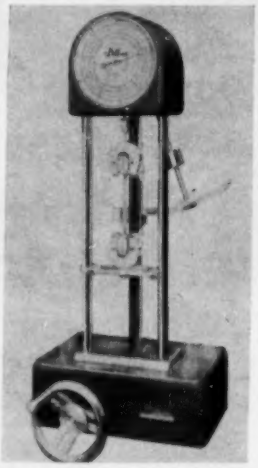
NEW INSTRUMENTS

DIGITAL VOLTMETER

New Model 484 Industrial Digital Voltmeter is said to be the only 4-digit DVM to offer printer connection and automatic print control for less than $2500. Accuracy is ±0.01%. Output operates an H-P 561-type digital data printer without modification. All stepping switches and decade resistors are mounted on plug-in epoxy boards. Input connections are located on both the front and back panels. It measures d-c voltage from ±0.001 to ±999.9 and features automatic selection and indication of range and polarity, an internal standard cell for verification of calibration, simple conversion to a ratiometer, high input impedance (10 megohms), heavy-duty stepping switches and compact design.—*Non-Linear Systems, Inc., Del Mar, Calif.*

CIRCLE 260 ON READER-SERVICE CARD

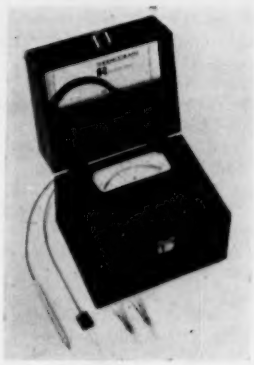
PORTABLE TEST INSTRUMENT



New Model M Tester for metal, plastics, textiles, wire, springs, leather, etc., is operated by means of a calibrated pendulum. Simple changes in grips quickly adapt the basic instrument for tests of tensile, compression, transverse, and shear forces. Guaranteed accurate within ½ of 1% of indicted reading in accordance with ASTM requirements. Five ranges, from 0-10 lb to 0-300 lb, are combined on the one 8" dial.—*W. C. Dillon & Co., Inc., 14620 Keswick St., Van Nuys, Calif.*

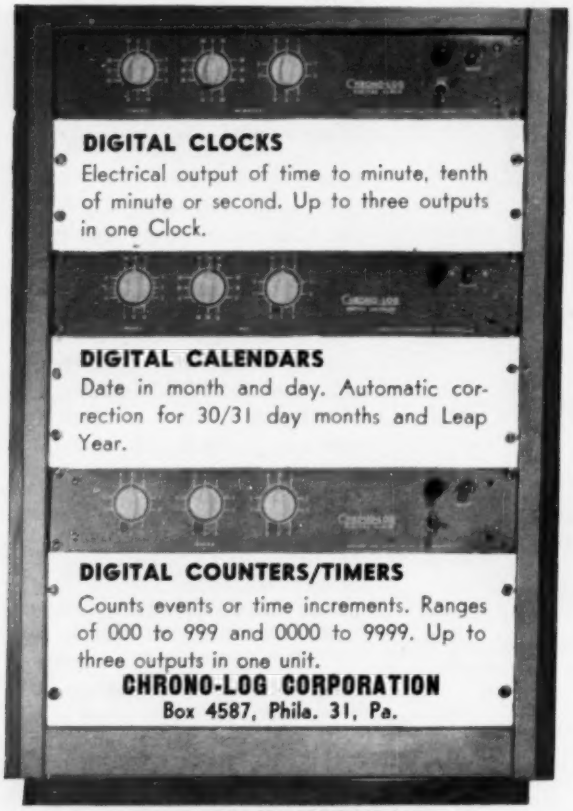
CIRCLE 261 ON READER-SERVICE CARD

TRANSISTOR TEMP TEST SET



New portable Thermograph which simplifies measurement of transistors, diodes, and other electronic equipment features automatic compensation. A special nomograph permits rapid determination of transistor and diode junction temperature. Accessories include small thermoelectric junctions, a convenient thermometer probe, and evacuated glass-enclosed thermocouples. Switches permit selection of any one of four outputs. —*Rescon Electronics Corp., Dept. 3151 Bear Hill Rd., Waltham 54, Mass.*

CIRCLE 262 ON READER-SERVICE CARD


DIGITAL CLOCKS
Electrical output of time to minute, tenth of minute or second. Up to three outputs in one Clock.
DIGITAL CALENDARS
Date in month and day. Automatic correction for 30/31 day months and Leap Year.
DIGITAL COUNTERS/TIMERS
Counts events or time increments. Ranges of 000 to 999 and 0000 to 9999. Up to three outputs in one unit.
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Box 4587, Phila. 31, Pa.

CIRCLE 104 ON READER-SERVICE CARD

Stearns electro-magnetic
miniature
CLUTCHES
STYLE "SM"*
Now Available in 6 Standard Sizes

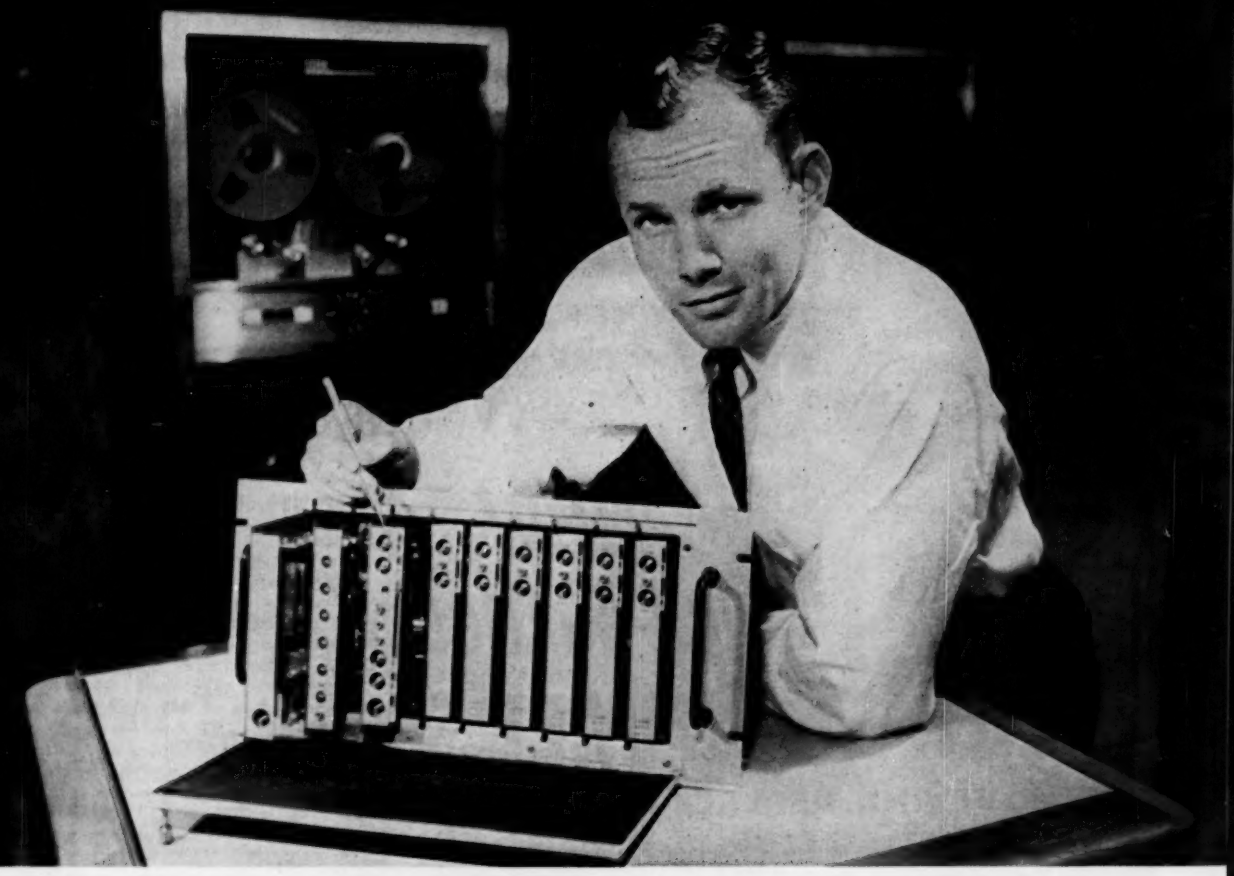
* Stationary Magnet

- Installation-Proved Reliability
- Wide Range of Size . . . from ⅞ in. to 4¼ in. Torque from 25 oz in. to 240 lb in.
- Heavy-Duty Construction
- Moisture-, Corrosion-Resistant
- Fast, Easy Installation
- Stationary Magnet
- Rapid Actuation
- Self-Adjusting
- Available with extended hubs for pulley mounting

For complete data, request Bulletin No. 504-BV

Stearns ELECTRIC CORPORATION
120 NORTH BROADWAY
MILWAUKEE 2, WISCONSIN

CIRCLE 105 ON READER-SERVICE CARD



Raytheon's Revolutionary A-D Converter Handles 5 Million Information Samples/Second

It is 100 times faster than any other available . . . about the size of an office typewriter . . . offers Industry and the Military a basic, solid state tool compatible with the speeds of newer electronic systems.

It can, with modification, scramble video signals . . . or ride inside a satellite or missile, converting temperature and other environment data.

Its applications encompass almost any product or process requiring continuous, automatic control of a constantly varying multiphase system.

Equipment employing this technique can digitize target information faster, enabling radar control systems to intercept or guide missiles or aircraft more accurately . . . help analyze an oil refining process, or the trajectory of an ICBM, in millionths of a second.

It is the most recent example of Raytheon Company Communications-Data Processing Capability.

MAIL COUPON TODAY FOR FOLDER & SPECIFICATIONS

Director of Marketing, Equipment Division,
Dept. E1, Raytheon Company, West Newton, Mass.

Please mail me further information on new 6-bit binary code A-D Converter. I am currently concerned with _____

_____

_____

_____
(type of system)

Name & Title _____

Company _____

Address _____

City & State _____

RAYTHEON EQUIPMENT DIVISION

Excellence in Electronics

CIRCLE 106 ON READER-SERVICE CARD

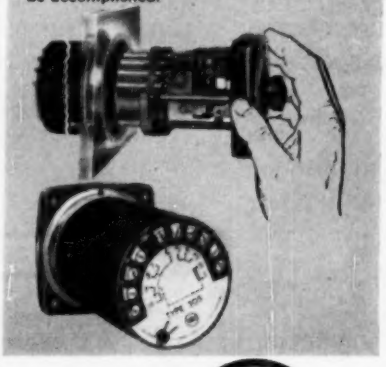
NEW QUICK-CHANGE "PLUG-IN" TIMERS

REMOVE AND REPLACE IN SECONDS

The new plug-in feature of the Atcotrol Reset Dial Timer permits fast, easy timer removal and replacement . . . keeps industrial process "down time" to a minimum because complete timer changes can be made instantly.

These Series 305 miniaturized timers control up to six individual load circuits, AC or DC, within variable timed intervals or sequences, with high repetitive accuracy. Able to perform 145 different circuit functions, they reset in less than 1/10 second, either stop or reset upon power interruption. As with all Series 305 timers, the plug-in model offers exclusive one-hole mounting.

WHEN INSTALLED, the plug-in model's plated, non-corrosive hex sockets engage plated banana plugs in a tubular case for positive spring pressure contact. A keyed guide pin aligns timer in its tubular encloser, protrudes through rear to accept a snap-in cotter pin clip, assuring continuous full-contact engagement. This safety clip must be removed before unplugging a "hot" timer, so that only authorized persons can make timer replacements. An optional front-mounting clamp is available for installation where rear accessibility cannot be accomplished.



PLUG-IN CONVERSION KIT

Standard Series 305 timers will continue to be made available for applications where the plug-in feature is not desired. These timers and those already installed, however, can easily be converted in the field to plug-in models.

For complete specifications and a schedule of prices, contact your nearest ATC sales office. Request Bulletin N-141.

atc

AUTOMATIC TIMING & CONTROLS, INC.

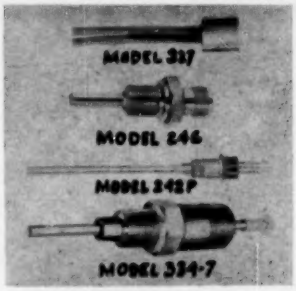
KING OF PRUSSIA, PENNSYLVANIA

A Subsidiary of American Manufacturing Company, Inc.

ATC, Div of Interprovincial Safety Industries, Ltd., 5485 Notre Dame St., West, Montreal 30, Quebec.

CIRCLE 107 ON READER-SERVICE CARD

TEMPERATURE DETECTORS



New Resistance Temperature Detectors are made in various types: (1) Model 313 resistance temperature detector has two concentric elements which permit measuring the same temperature at two different locations or permits indication and recording simultaneously. (2) Model 327 is only ¼" long x 0.278" in dia. The sensing element or winding of the detector is located in the first 0.060" of the tip for fast response to temperature changes. (3) Model 246 detector made of 403 stainless steel has a ¾"-16 UNF-3 mounting thread and withstands pressures of 5000 psi. (4) Model 242P is hermetically sealed in its own well for use under pressures up to 300 psi and can be used in any standard ⅜" bore thermowell for higher pressures for the measurement of highly corrosive liquids or gases. (5) Model 334-7 is explosionproof for use in Class I Group C & D, Class II Group E, F & G, and Class III locations.—*Thomas A. Edison Industries, Instrument Div., McGraw-Edison Co., West Orange, N. J.*

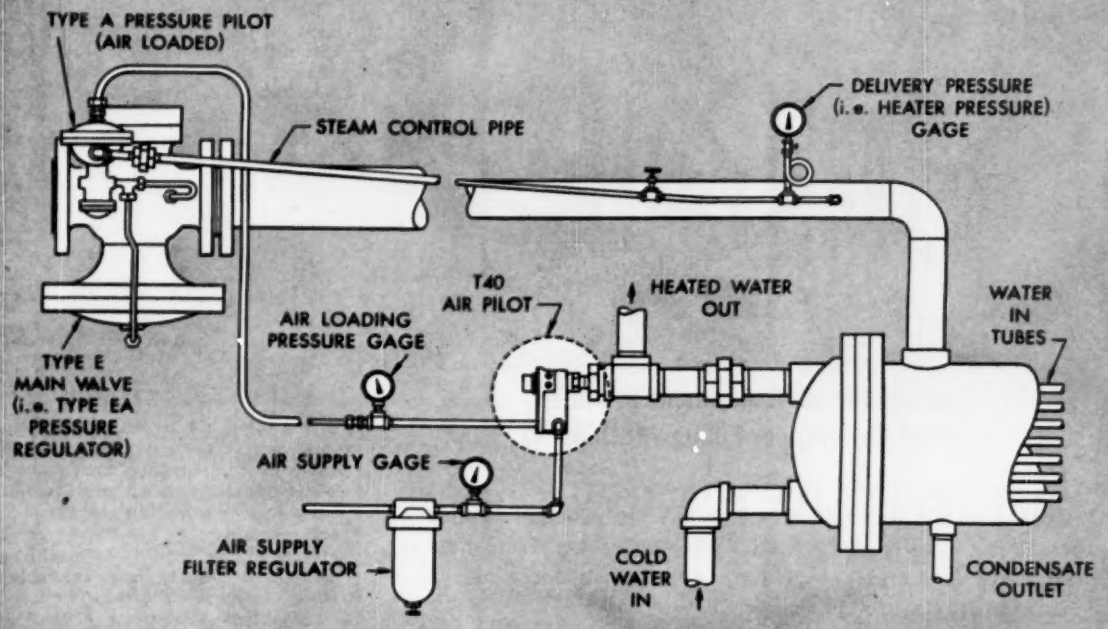
CIRCLE 263 ON READER-SERVICE CARD

NETIC TAPE CONTAINER

New 10" single-reel Netic Magnetic Tape Container simplifies identification of program material contained within while affording ultimate magnetic shielding against tape erasure or the introduction of noise from unpredictable and extraneous magnetic fields during storage and transport.—*Magnetic Shield Div., Perfection Mica Co.*, 1322 *N. Elston Ave., Chicago 22, Ill.*

CIRCLE 264 ON READER-SERVICE CARD

New Spence Temperature Control System with Cascade Control Accuracy at Regulator Costs


TYPE A PRESSURE PILOT (AIR LOADED)
STEAM CONTROL PIPE
DELIVERY PRESSURE (i.e. HEATER PRESSURE) GAGE
T40 AIR PILOT
HEATED WATER OUT
WATER IN TUBES
AIR LOADING PRESSURE GAGE
TYPE E MAIN VALVE (i.e. TYPE EA PRESSURE REGULATOR)
AIR SUPPLY GAGE
AIR SUPPLY FILTER REGULATOR
COLD WATER IN
CONDENSATE OUTLET

TYPE EAT40 AIR-CONTROL TEMPERATURE REGULATOR (Patent Pending)

In a recent installation the new Spence air-control temperature regulating system provided:

- ±5°F control accuracy under wide and instantaneous load swings of 210 to 80 gallons per minute.
- Up to 50% reduction in cost as compared to instrument systems of similar accuracy.

This unique cascade-type control with throttling range adjustment independent of maximum heater pressure was developed to meet today's demand for greater control accuracy.

Additional features of the new Spence Temperature Control System include:

- 200°F wide adjustable temperature range
- Adjustable speed of steam pressure change
- Over and under temperature protection
- Pressure limit control
- Fast response
- Very low air consumption
- Field reversible for heating or cooling

The Spence Type EAT Air Control Temperature System, when properly installed, will tame wide ranging, fast changing loads of instantaneous heaters and modern heat exchangers. The cascade principle plus the use of an extremely fast responding bi-metal temperature sensing element reduce time lags and provide control stability.

Here's how the new Spence system operates:

Quick response is based on a bi-metal temperature sensing element.

Temperature pilot continuously regulates a loading air pressure.

This loading signal, when applied to a pressure regulator to reflect heater temperatures, causes it to adjust the main valve as changes in load require.

Spence has also developed a new pressure control system based on this same cascade principle. This system has a control accuracy of ½ psi or better from positive pressures through the vacuum range to 30" Hg.

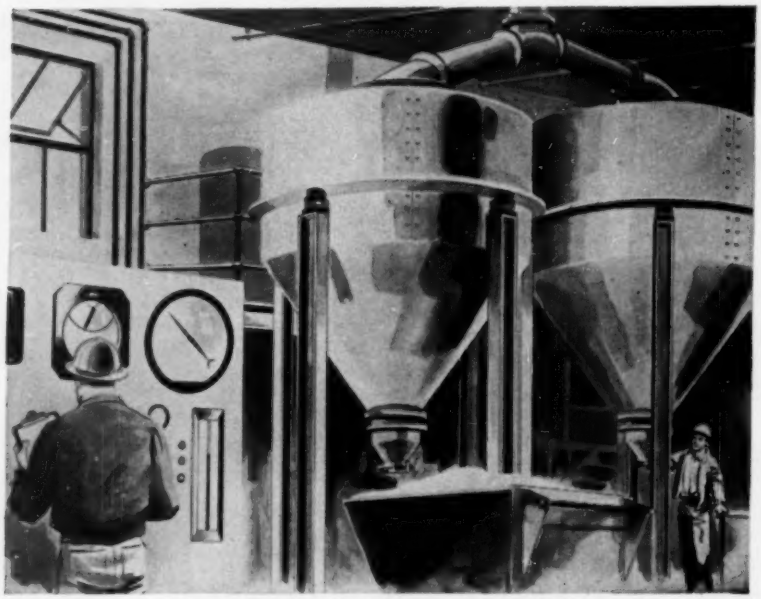
For complete information on these new air controlled temperature and pressure control systems, write for your copy of Bulletin 9.

SPENCE ENGINEERING COMPANY, INC.
Walden, New York SE-148A

CIRCLE 108 ON READER-SERVICE CARD

EMERY ENGINEERED WEIGHING SYSTEM

Provides Maximum Accuracy for Pulverized Vitamin C Installation



Explosion-Proof Equipment Provides Control For Hopper-Filling Mechanism

A pharmaceutical manufacturer wanted to weigh powdered ascorbic acid as part of its process in making Vitamin C tablets. The powder is gathered in hoppers which weigh 3500 pounds and handle a maximum net load of 8750 pounds.

The conditions demanded that the equipment be explosion-proof and that the weighing signal be used to actuate automatically a diverting gate in the filling system which would switch the in-flow from one hopper to another.

An Emery Engineered Weighing System, based on the use of 4 Model EC-30 load cells and a hydraulic totalizer and using a 16" Emery Precision Indicator together with a Foxboro controller, handled the hopper-weighing job with an accuracy of ¼% of full range. Customer satisfaction is guaranteed.

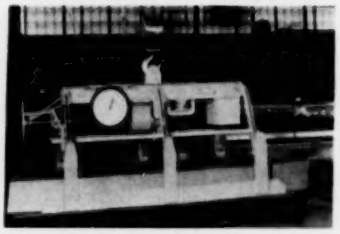
If you have a tank, bin or hopper weighing problem which involves a control function, write today. Our literature is graphic, descriptive and easy to use in figuring a system for your installation. The A. H. Emery Company, Pine Street, New Canaan, Conn.

EMERY *Engineered* weighing systems

CIRCLE 109 ON READER-SERVICE CARD

IGS NEW INSTRUMENTS

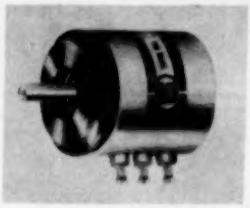
SHEET-LIFTER WEIGHING



New hydraulic Weighing Attachment for C-F sheet lifter weighs each load lifter and automatically indicates on a large easy-to-read dial.—*Martin-Decker Corp., 3431 Cherry Ave., Long Beach 7, Calif.*

CIRCLE 265 ON READER-SERVICE CARD

WIREWOUND POTENTIOMETER



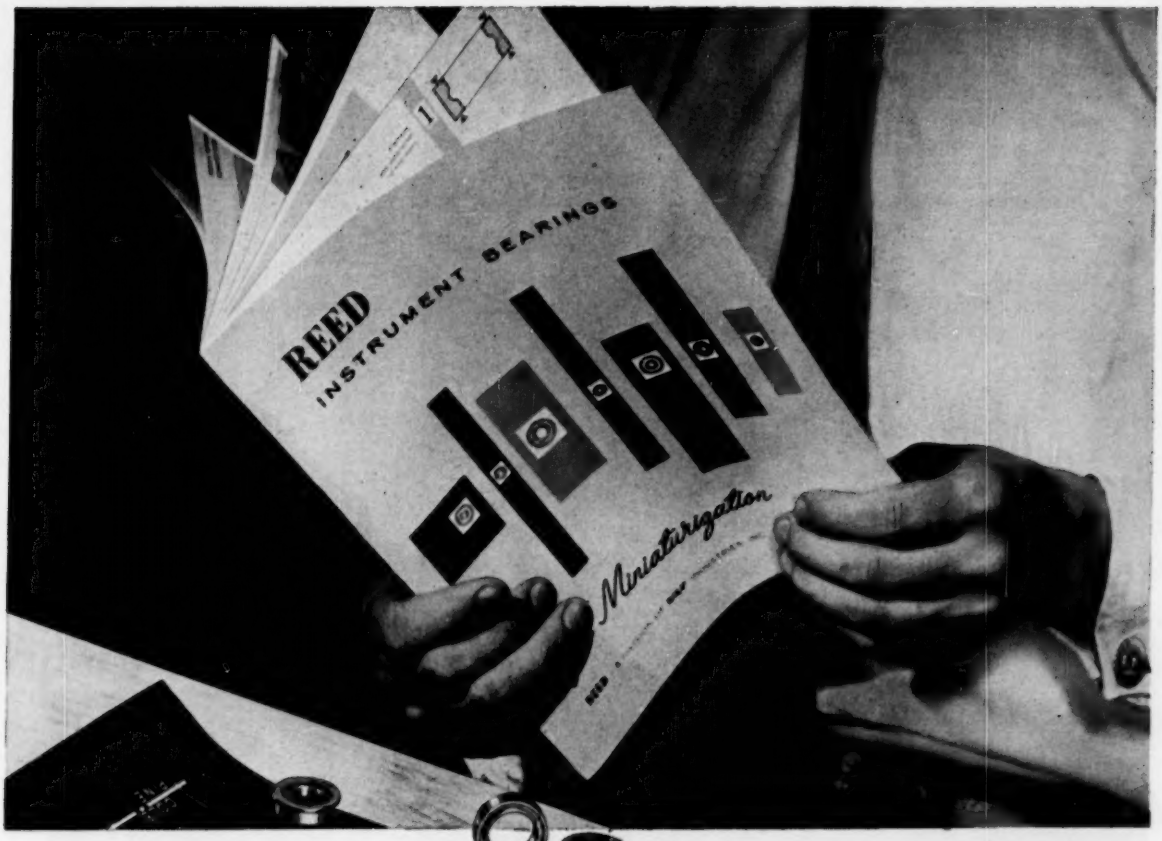
New 2100 Series of ⅞"-dia wire-turn and three-turn models, are capable of withstanding more than 1,000,000 revolutions without exceeding resistance or linearity tolerances. Total resistances to 100,000 ohms are offered. Two types of mountings, servo and bushing, are available.—*Borg Equipment Div., Amphenol-Borg Electronics Corp., 120 South Main St., Janesville, Wis.*

CIRCLE 266 ON READER-SERVICE CARD

PULSE GENERATOR

New low-frequency Pulse and Waveform Generator Model P-1, generates virtually transient-free pulses, square triangular, and sine waves of high purity. Instruments which supplies sufficient power to drive power transistors and relays, electrohydraulic valves, and other physical elements directly from output terminals, is continuously variable in 10 frequency ranges, from 0.01 cps to 2000 cps. Pulse length is continuously variable from 100 μsec to 10 sec.—*Parabam, Inc., 13000 Yukon Ave., Hawthorn, Calif.*

CIRCLE 267 ON READER-SERVICE CARD



The REED catalog gives you

QUICK ANSWERS TO TOUGH QUESTIONS ABOUT INSTRUMENT BEARINGS

Should we specify ABEC-7 instead of ABEC-5? What's the recommended lubricant: oil or grease? What shaft and housing tolerances shall we use? Should extended inner ring bearings be specified for the application?

Questions like these can fly fast and furious when you're on a project. That's exactly when you need REED's catalog on instrument bearings. Because, this small but specific reference combines valuable information with vital statistics on instrument bearings. There's no nonsense—just facts. Data on load ratings, fits, tolerances, etc. are all easy to find.

REED specialists are also readily available to help you with any bearing problem, large or small. These men are specially trained and experienced—fully able to make tiny bearings do big, important jobs. And they're located near you, as shown in the box at right. 6017

For a copy of the REED Instrument Bearing Catalog—or help with an instrument bearing problem—call or write:

REED Instrument Bearing Company
Div. SKF Industries, Inc.

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4241 Redwood Avenue
Los Angeles 66, Calif.
Phone: UPton 0-5814 or
EXmont 8-3204

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Front Street and Erie Avenue
Philadelphia 32, Pa.
Phone: GArfield 6-6400

•

20 Henry Street
Teterboro, N. J.
Phone: ATlas 8-1700 or
PEnnsylvania 6-9767 (N.Y.C.)

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1800 N. 25th Avenue
Melrose Park, Ill.
Phone: FIllmore 4-1035 or
MAnsfield 6-7456 (Chicago)

REED INSTRUMENT BEARING COMPANY
LOS ANGELES, CALIFORNIA

Division of
SKF®
INDUSTRIES, INC.

CIRCLE 110 ON READER-SERVICE CARD

ANTI-PARALLAX FACE

Anti-parallax BIMET® face eliminates reading errors when dial is viewed from any angle.

STAINLESS STEEL CASE

Stainless Steel Construction throughout, including the most rugged Polished Stainless Steel Case available for the ultimate in corrosion resistance and strength, is exclusively provided on all Moeller BIMETS.

Moeller Features

HERMETICALLY SEALED

Hermetically sealed with dry air to prevent entry of moisture and condensation throughout the life of the instrument.

RECALIBRATION

Exclusive Moeller external recalibration feature provides adjustment of pointer on scale so that scale is always upright and easily readable. Thermometer remains sealed. Only Moeller BIMETS offer the convenience and error-free readability of vertically oriented dials.

Provide Timeless Accuracy

You'll appreciate the superior accuracy, reliability and rugged construction of the NEW 3" and 5" BIMET® Thermometers. Silicon dampening stabilizes the pointer against vibration assuring precise reading and reduced wear.

Moeller BIMETS offer superior reliability of measurement, easy, accurate reading, the most rugged construction, simplicity of installation and guaranteed accuracy of 1% of full scale.

The NEW 3" and 5" BIMETS are available for ranges from −100°F to +1000°F or −70°C to +500°C with glass or plastic fronts. Standard ¼" or ⅜" O.D. stems, up to 100" in length may be ordered in any angular position. Moeller exclusive swivel nuts or fixed connections are furnished.

Get your copy of BIMET® Catalog #225D from your Moeller Representative or write

SINCE 1867

MOELLER INSTRUMENT COMPANY, Inc.

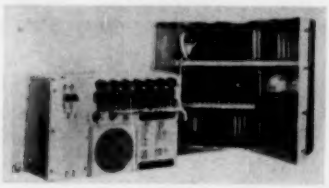
132nd Street and 89th Avenue, Richmond Hill 18, N.Y.

Representatives in principal cities

BIMET is a registered trademark of Moeller Instrument Company, Inc.

CIRCLE 111 ON READER-SERVICE CARD

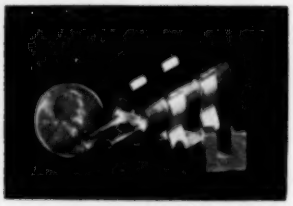
RANDOM ACCESS MEMORY



New small General Purpose Memory, Type RB, provides asynchronous operation at rates to 200 kc and is available in capacities from 128 to 1024 words with word lengths from 4 to 24 bits. Among the features claimed are long-term reliability, low cost, a wide range of capacities, and a variety of operating modes. They can be operated in a random access mode, as sequential access buffers, or any combination of both without loss of speed.—*Telemeter Magnetics Inc., Box 329, Culver City, Calif.*

CIRCLE 268 ON READER-SERVICE CARD

AIR SWITCH & RELAY VALVE



New Pneumation miniaturized Air Switch and Relay Valve consists (1) of an air switch which is a magnetic proximity air valve for on-off control in pneumatic circuits, a plug-in unit weighing less than two ounces, operated by a small magnet carried by a moving member of a mechanism, and (2) a relay valve which is a plug-in unit with capacity to control pneumatic equipment. A typical application is in automatic weighing to start and stop the flow of material.—*Associated Control Equipment, Inc., Box 136, Coraopolis, Penna.*

CIRCLE 269 ON READER-SERVICE CARD

DUAL POWER SUPPLY

New compound-regulated Dual Power Supply, Model R-300, consists of two separate regulated supplies on one chassis, with a comon reference, which provides ±300 vdc, each rated at 300 ma. The supply also provides four line voltage connections, at the output connector, fused and switched at the main power switch. A separate front panel switch is provided for applying the + and−300 vdc. Details in data sheet.—*George A. Philbrick Researches, Inc., 285 Columbus Ave., Boston 16, Mass.*

CIRCLE 270 ON READER-SERVICE CARD

Nash Instrument Air Compressors deliver only clean air, free from oil or dust, and without filters
INLET PORT
DISCHARGE PORT
DISCHARGE PORT
INLET PORT
ROTATION IS CLOCKWISE

Here is Why!

You can dispense with oil filters and dust filters when you install ®Nash® Clean Air Compressors. You can save the cost of maintaining these devices. You can greatly reduce instrument maintenance costs. For the Nash employs no internal lubrication, therefore no troublesome oil is in the delivered air. Moreover, air from a Nash is thoroughly washed and cooled as it passes thru the pump. Dust in the plant atmosphere, even fly ash, is immediately removed.

®Nash® Clean Air Compressors are simple, with only one moving element. No valves, gears, pistons, sliding vanes, or other enemies of long life and constant performance complicate a Nash. No aftercoolers are needed. You will find it profitable to investigate these pumps, now.

No oil filters.
No dust filters.
No internal lubrication to contaminate air handled.
No internal wearing parts.
No valves, pistons, or vanes.
Non-pulsating pressure.
Original performance constant over a long pump life.
Low maintenance cost.

NASH ENGINEERING COMPANY
370 WILSON, SO. NORWALK, CONN.

For SIMPLIFIED TRANSISTOR and DIODE TEMPERATURE MEASUREMENTS

THE NEW RESCON TRANSISTOR THERMAL TEST SET

This single, self-contained unit provides complete facilities for temperature measurement problems in designing electronics equipment. It is especially applicable for determining transistor junction temperature measurements.

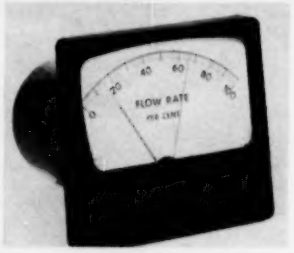
Determination of heat sink efficiencies, temperature rises, thermal environmental conditions, location of "hot spots", heat transfer efficiency of transistor mounts, and thermal gradients of the overall equipment are just a few of the unlimited applications.

The Thermal Test Set is easy to use — all readings are accurate and *direct* — no batteries, power compensations, calibrations or complex instructions required. Rugged construction for long-term service.

RESCON
ELECTRONICS CORPORATION
151 Bear Hill Road, Waltham 54, Massachusetts

CIRCLE 112 ON READER-SERVICE CARD

MAXIMUM READING METER



New type of Maximum Reading Meter, combining a meter-relay movement and special circuitry to show the highest level reached by an electrical signal, features an adjustable pointer with the feature that until reset the meter remains at the maximum signal reached over any period of time. The other pointer provides continuous signal indication. Meter is available in these ranges: 0-10 mamp to 0-50 amp or 0-5 mv to 0-500 v ac or dc. Case styles are 2½" round and 4½" rectangular.—*Assembly Products, Inc., Chesterland, Ohio.*

CIRCLE 271 ON READER-SERVICE CARD

MILLIVOLTMETER

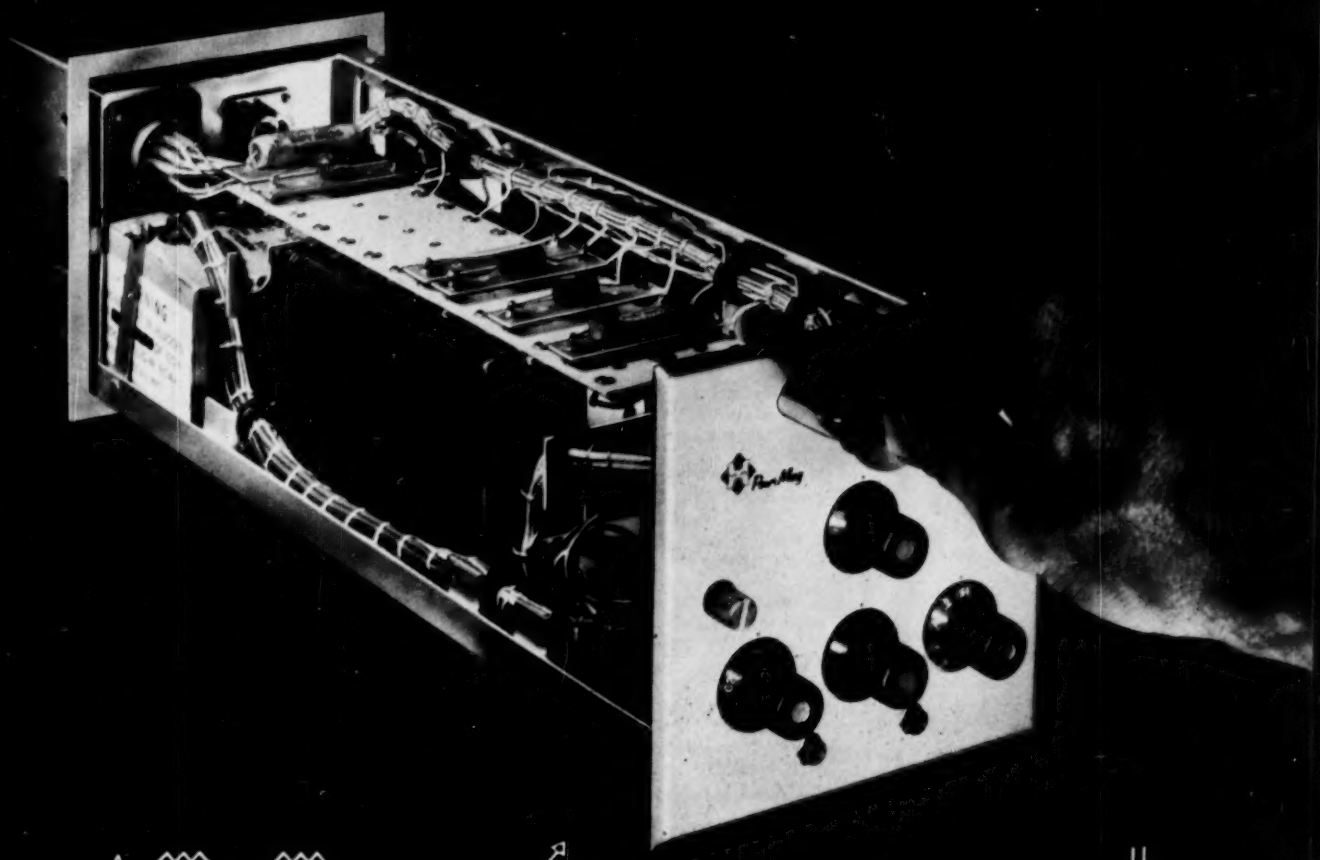
New all-transistorized, portable Audio-RF Millivoltmeter, providing accurate measurements down to 100 mv over a frequency range of 20 cps to 20 Mc with full scale readings in 12 ranges from one mv to 300 v, has a built-in video amplifier for simultaneous use with meter to drive an oscilloscope. Accuracy is within ±3% of full scale between 100 cps and 5 Mc and within ±5% from 20 cps to 20 Mc.—*Motorola Inc., Communications and Industrial Electronics Div.,* 4501 *West Augusta Blvd., Chicago* 51, *Ill.*

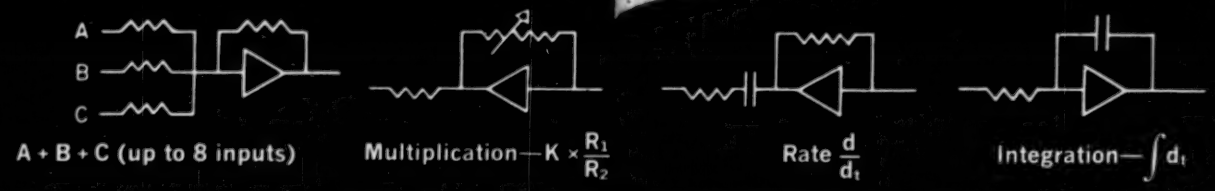
CIRCLE 272 ON READER-SERVICE CARD

P/S FOR STRAIN GAGES

Six new standard models of transistorized Power Supplies for strain gages have continuously-variable output ranges from 0 to 30 v and 0 to 200 mamp at input of 117 v (95-135)/60 cps. Power supply noise level across a grounded 350 ohm bridge is held to 1.00 μv peak-to-peak typical. Line voltage regulation is held constant within 0.03% and load regulation within 0.03%.—*Computer Engineering Associates, Inc.,* 350 *North Halstead, Pasadena, Calif.*

CIRCL 273 ON READER-SERVICE CARD





MAGNETICALLY—ONE CONTROLLER for all control functions

Hagan's PowrMag controller combines the kind of reliability required by industry with a flexibility of application that makes this one controller suitable for all control actions. Utilizing a high gain, operational magnetic amplifier, PowrMag can produce the full range of control actions by simple negative feedback through ordinary resistors or capacitors. These "passive network" elements are simply and easily plugged into the basic amplifier chassis by means of an integral plug-board, as shown in the photograph.

Here are some of the characteristics that make the PowrMag so valuable to a control system designer . . . Control signals—1 to 9 v DC *(no noise, capacitive loss or phase shift problems)*—Entire amplifier potted and then encased in steel *(virtually unaffected by environment)* — Utilizes unregulated 110 v AC power supply *(uses only 3 watts of power)* —Full integration action from a minimum change *(high sensitivity)* —Modular construction *(no inventory problems—each unit can perform any given function by a simple change of plug-in components)* — Each module is equipped with a pilot light to indicate fuse failure, test jacks to plug in an output meter, calibrated knobs for set point (bias), gain, reset and rate. Components can be replaced without a soldering operation *(minimum maintenance)*.

The Hagan PowrMag line includes the controller, remote control stations, patchboards for interconnecting the system, sensing elements and final operators. Why not phone or write for a Hagan engineer to give you all the facts on this remarkable system.

HAGAN
CHEMICALS & CONTROLS, INC.
HAGAN CENTER, PITTSBURGH 30, PA.

HAGAN DIVISIONS: CALGON CO. • HALL LABORATORIES • BRUNER CORP.

CIRCLE 113 ON READER-SERVICE CARD

NEW INSTRUMENTS

A-C VTVM

New A-C Vacuum Tube Volt Meter, Model 715, features high input impedance, multi-voltage ranges, and wide frequency response which make it ideal for hi-fi and general low-level audio work such as hum and ripple measurements, IF gain, and vibration analyzing. Details in Catalog Sheet ST-301A.—*Simpson Electric Co., 5200 W. Kinzie St., Chicago 44, Ill.*

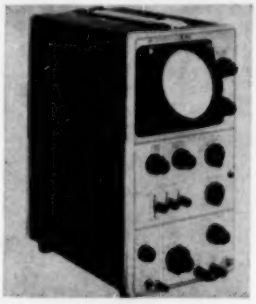
CIRCLE 274 ON READER-SERVICE CARD

ALL-ELECTRONIC DIGITAL VOLTMETER

New all-electronic Digital Voltmeter, Model V44, is for measuring and data logging applications that demand maximum speed with stability and reliability matching that of electromechanical instruments. It makes 200 readings/sec in ranges of ±9.999/99.99/999.9 vdc. Accuracy is ±1 digit and input impedance is 10 megohms. As there are no pots at all in the decade circuits, there is no need for periodic adjustment of trim pots in decade circuits. Balancing time is 5 usec which permits high-speed measurement of transient data in such applications as missile check-out, laboratory research, and high-speed production testing. All basic circuitry is mounted on plug-in modules for maximum ease and speed of servicing. A snap-out readout makes bulb replacement easy.—*Non-Linear Systems, Inc., Del Mar, Calif.*

CIRCLE 275 ON READER-SERVICE CARD

PORTABLE OSCILLOSCOPE



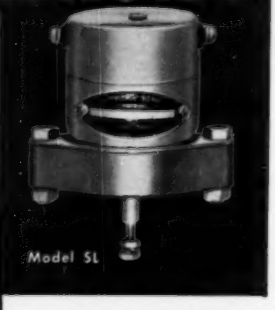
New high-writing-speed Oscilloscope, Model S42, uses a new 4" cathode-ray tube with extremely fine focus. Operating at 3.7 kv, brightness is such that a 1-μsec "single shot" pulse can be seen and photographed. Balanced low-drift amplifiers have bandwidth of dc to 6 mc up to 100 mv/cm, and a high gain facility gives 10 mv/cm sensitivity with bandwidth limited to 500 kc. Features include time and voltage calibration with built-in squarewave calibrator, automatic sync and selective triggering, 9-position frequency-compensated attenuator and 18-speed time base with X 10 expansion, giving maximum speed of 0.1 μsec/cm.—*Scopes Co., Box 56, Monsey, N. Y.*

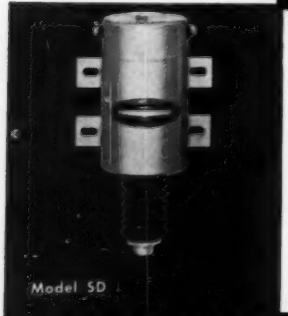
CIRCLE 276 ON READER-SERVICE CARD

HEAVY DUTY D. C. SOLENOIDS

MODEL SL

VOLTAGES .....(D.C. Only) 6V. 12V. 24V. 32V.
CURRENT DRAW....(Pulling) 55A. 35A. 15A. 12A.
CURRENT DRAW...(Holding) 1.6A. .8A. .4A. .3A.
DUTY .....Continuous
CYCLES..... Not to exceed 6 per minute
PULL...Approximately 10 lbs. over ½ inch stroke
WEIGHT.....2½ pounds





MODEL SD

VOLTAGES .....(D.C. Only) 12V. 24V. 32V. 115V.
CURRENT DRAW....(Pulling) 40A. 20A. 15A. 4A.
CURRENT DRAW...(Holding) .5A. .25A. .20A. .05A.
DUTY .....Continuous
CYCLES..... Not to exceed 6 per minute
PULL...Approximately 10 lbs. over 1½ inch stroke
WEIGHT.....4¼ pounds
Model SM available with 1 inch stroke.

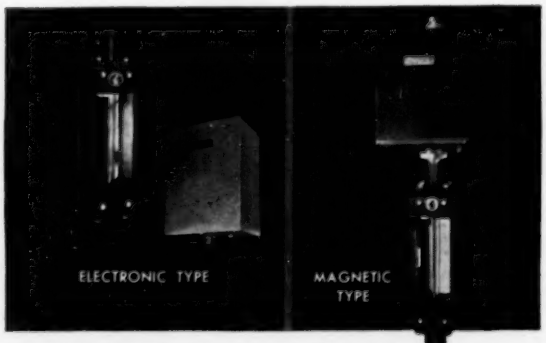
SYNCHRO-START PRODUCTS, INC.
8151 N. RIDGEWAY AVENUE • SKOKIE, ILL.

CIRCLE 114 ON READER-SERVICE CARD

ALARM ROTAMETERS

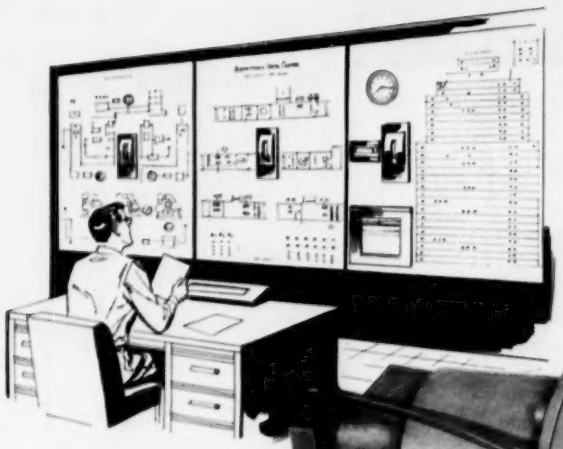
SIGNAL ABNORMAL FLOW RATES

SK Alarm Rotameters accurately measure fluid rate of flow—activate a light or alarm device, start or stop a pump, motor, control unit *in case of abnormal flows.* They are accurate, economical, dependable. Get details in new Bulletin 18A.



Schutte and Koerting COMPANY
INSTRUMENT DIVISION
2225 STATE ROAD, CORNWELLS HEIGHTS, BUCKS COUNTY, PA.
EXPORT DEPT.: 1505 Race Street, Philadelphia 2, Pa., U.S.A.

CIRCLE 115 ON READER-SERVICE CARD



This DeZurik Control Valve has ALL the features you want!

WHY SETTLE FOR LESS?

When DeZurik Control Valves, because of their resilient plug facing and eccentric action, shut dead-tight, why settle for even .1% leakage? When straight-thru flow permits higher capacity (a 1″ DeZurik Valve has a flow coefficient of 33, a 3″ valve 330, a 10″ valve 3130!), why take less? When DeZurik eliminates stem leakage with a rotary stem seal kept under constant spring pressure, why accept even minute leakage to atmosphere? When DeZurik Control Valves feature manual operation provision as standard on all models, why pay extra for it?

In short, when DeZurik Control Valves offer you all the precision . . . the versatility . . . the dependability you want and at low cost, why settle for less?

For more details on DeZurik Control Valves see the DeZurik representative in your area, write for Bulletin 150, or see us at the New York ISA Show.

DeZURIK CORPORATION
SARTELL, MINNESOTA

CIRCLE 116 ON READER-SERVICE CARD

REC's.....

Precision Temperature Probes.....at off the shelf prices!

Want low cost temperature probes on short notice – without sacrifice in quality? Rosemount Engineering Company now offers high-performance platinum resistance temperature sensors from stock.

MODEL 179A

Sensing element fully supported, mounted in ceramic insulation. Stainless steel guard tube with additional support at the element tip gives maximum protection from flow.

MODEL 179A

MODEL 152T

MODEL 152T

Sensing element supported by a light cage and exposed to working fluid to give extremely fast response in fluids which are not electrical conductors. Element protected by stainless steel guard tube with additional support at the element tip.

Fourteen stem lengths and 6 different fittings of each model available. These immersion probes have wide application in research, development and industrial process controls. Recommended for use in most hydrocarbons, gaseous or liquid air, oxygen, nitrogen, hydrogen or helium. Sensing elements, of precision platinum, are calibrated at liquid helium point and the ice point. General specifications:

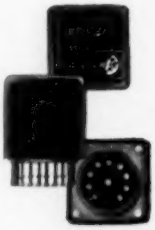
- Temperature Range – from –435°F to 500°F
- Stability – Stable within 0.20°F at 32°F
- Pressure – 6,000 psi maximum
- Element Length – from 1⅛" to 2¾", in ⅛" increments
- Time Constant – 152T – 0.2 seconds } Dow Corning No. 200
  179A – 0.5 seconds } 1.5 CTSK Oil
- Resistance at 32°F – 152T – 200 ohms
  179A – 500 ohms

For additional information write for advance bulletin number 5603.

Plus Circuit Modules

Rosemount also offers a series of preassembled circuit components, featuring small size and durability. Built to meet environmental requirements of MIL-E-5272 and MIL-E-8189.

- General purpose amplifier, Model 510A, 40 db voltage gain minimum, 10 cps to 100,000 cps, –55°C to 125°C.
- High impedance input amplifier, Model 511A, 20 db power gain, input impedance greater than 1 x 10^6 ohms, 10 cps to 50,000 cps, –55°C to 125°C.
- Power supply, Model 531A, 117 volts, 400 cps; 20 volt DC regulated, 10 milliamperes, 0.1 percent ripple, –55°C to 125°C.
- Rectifier-filter, Model 532A, diodes and RC filter for two full wave DC supplies. Rated 30 volts DC each at 0.1 percent ripple, –55°C to 125°C.



(Size 1 x 1 x 1 Inch)

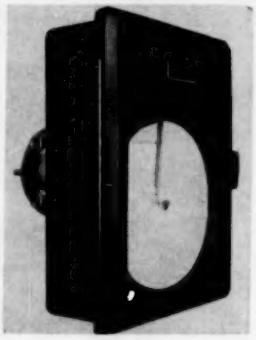
For additional information write for advance bulletin 46028.

ROSEMOUNT ENGINEERING COMPANY

4900 West 78th Street, Minneapolis 24, Minn.

CIRCLE 117 ON READER-SERVICE CARD

FLOW RECORDER



New Model 202A Flow Recorder, an improved version of Model 202, is actuated by Model 199 rupture-proof meter body and incorporates many improved features such as all internal parts made from stainless steel, micro-linearity adjustment on the torque tube drive arm, and micrometer adjustments for zero and range.—*Barton Instrument Corp., 580 Monterey Pass Rd., Monterey Park, Calif.*

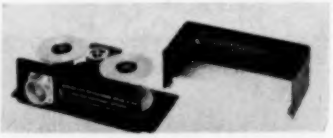
CIRCLE 277 ON READER-SERVICE CARD

EPOXY RESIN KIT

New one-part Epoxy Resin Powder, Scotchcast brand XR-5026, for use in insulating electrical and electronic components, is available in a test kit which serves also as a powder aerator for experimental applications. Electrical properties of the resin include an electric strength of 500 to 800 v/mil; a dielectric constant of 3.61 at 23°C and 60 cps, and a dissipation factor of 0.0053 at 23°C and 60 cps.—*Minnesota Mining and Mfg. Co., 900 Bush Ave., St. Paul 6, Minn.*

CIRCLE 278 ON READER-SERVICE CARD

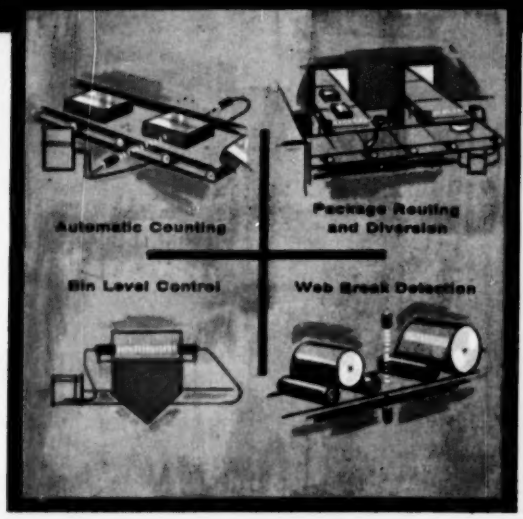
TAPE PROGRAMMER



New airborn-type TP-813 Programmer is mechanically and electrically interchangeable with similar units. It has a tape capacity of 75' of 35-mm Mylar film or equivalent to a 20-min program at standard speed of 0.748"/sec. Contacts are rated at 0.4 amp. Programs can be changed or altered in a matter of seconds to suit new requirements and conditions. Accuracies in the order of one ppm over a program period of 20 min are obtained.—*Electronic Engineering Co., Anaheim Electronics Div., 1601 East Chestnut Ave., Santa Ana, Calif.*

CIRCLE 279 ON READER-SERVICE CARD

a new dimension in automated controls



SONAC ULTRASONIC,

NON-CONTACT SENSING AND SWITCHING SYSTEM

Before Sonac, sensing and switching control systems which involved breaking a beam of energy were limited by vibration, dust, smoke, steam, air contamination and too much or too little light. Sonac's ultrasonic energy "beam" is completely free of these limitations. The acoustic lens on Sonac sensors can actually be painted without affecting performance. Utilizing high frequency sound also means there are no lamps to burn out. Savings in replacement parts and maintenance time often means Sonac pays for itself. Sonac is completely transistorized, providing you with a rugged, dependable electronic circuit.

These are just a few of Sonac's many uses. Optional equipment includes reflectors for precision beam and positioning control, and coupler assemblies for use with flexible tubing for remote sensor locations. This descriptive booklet will be sent to you on request.

DELAVAN Manufacturing Company
WEST DES MOINES • IOWA

CIRCLE 118 ON READER-SERVICE CARD

The Mastergauge GROUP

and companion "Master-test" group for extreme services requiring the ultimate in accuracy and stamina.

Right Quality GROUP

also for tough services, but less severe than the conditions served by the "Mastergauge"

Gauge Standard GROUP

for the general run of gauge services. Marsh quality and accuracy at a moderate price.

for every need

Within these three comprehensive Marsh groups you have the world's widest (yes, and wisest) selection of pressure gauges. These groups of gauges are not *grades* ...they are *kinds*...the MARSH kind... which means that each gauge, within the scope of its rated use, is the BEST of its kind!

Pick the right Marsh Gauge and you have the best answer to your gauge problem.

Ask for latest data

MARSH INSTRUMENT COMPANY

Division of Colorado Oil & Gas Corporation, Dept. 42, Skokie, Ill. Marsh Instrument & Valve Co., (Canada) Ltd., 8407 103rd St., Edmonton, Alberta, Canada. Houston Branch Plant, 1121 Rothwell St., Sect. 15, Houston, Texas.

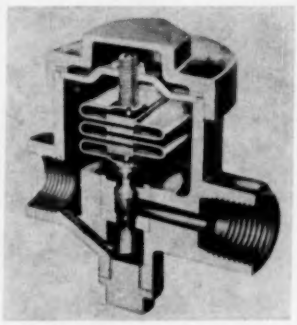
MARSH

Booth Nos. 1543-1544-1643
New York I.S.A. Show, Sept. 26-30

CIRCLE 119 ON READER-SERVICE CARD

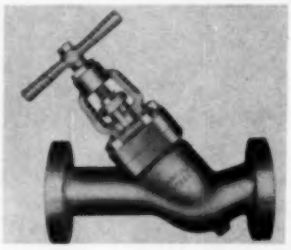
THERMOSTATIC STEAM TRAPS

New line of low cost, Thermostatic Steam Traps includes high and low pressure types in pressure-balanced thermostatic and float-thermostatic designs. Unaffected by pressure, water hammer, frost, corrosion or rough handling, operation is maintained by a patented, indestructible, stainless steel, bi-metal thermal element with universal joints. This unique thermal element responds only to temperature and has proved more reliable than bellows and diaphragm types of steam traps which are subject to failure.—*Farris Engineering Corp., MIL Div., 610 Commercial Ave., Palisades Park, N. J.*



CIRCLE 280 ON READER-SERVICE CARD

BLOW-OFF & DRAIN VALVES



New line of Hancock Blow-Off and Drain Valves for process steam applications, heating, and public utilities features "Blo-Deflector" seat discs which keep the seating surface completely out of the line of flow, affording long-term service. Supplied in both straightway and angle types in 300# and 600# classes in 1½", 2" and 2½" sizes.—*Manning, Maxwell & Moore, Inc., Stratford, Conn.*

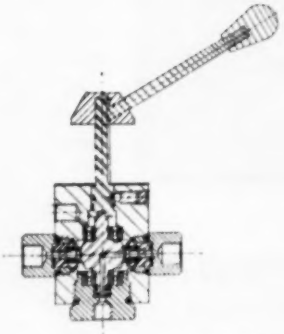
CIRCLE 281 ON READER-SERVICE CARD

OCTAVE BAND ANALYZER

New transistorized Model 532 Octave Band Analyzer is for analysis of environmental noises and complex audio signals, production line testing, noise level acceptance and speech interference levels. Bands are marked with the center frequencies using the ASA S-1.6-1960 Preferred Frequencies. Battery operated, it has low power consumption, and yet has a dynamic range of 66 db.—*Allison Labs., Inc., 11301 E. Ocean Ave., Dept. 137, La Habra, Calif.*

CIRCLE 282 ON READER-SERVICE CARD

SELECTOR VALVE



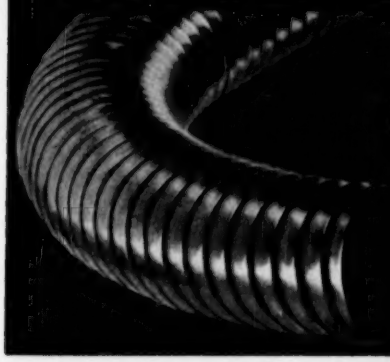
New six-position manually-operated Multiple Selector Valve for hydraulic circuits features a unique spherical rotor design which permits the selection of flow from any one of six sources, or directs one flow to any one of six circuits. Built for 0-to-6000-psig operating pressure and 10,000-psig proof pressure, the valve has a rated flow capacity of 0.5 gpm. Available with ¼" NPTF and ¼" SAE ports.—*Sarasota Precision Products, Inc., 5757 McIntosh Rd., Sarasota, Fla.*

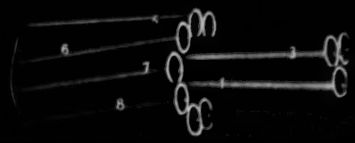
CIRCLE 283 ON READER-SERVICE CARD

CRESCENT

NYLON MULTITUBE

NEW





with INDIVIDUALLY NUMBERED TUBES

NYLON TUBES: TOUGHER AND STRONGER THAN POLYETHYLENE TUBES COST LESS THAN COPPER TUBES

CRESCENT NYLON MULTITUBE employs SPIRALLY CABLED, long-length tubes of black pigmented, heat-stabilized nylon for maximum resistance to environmental deterioration. The SPIRALLY CABLED tubes permit maximum flexibility and bending with no distortion or stress on the tubing.

CRESCENT NYLON MULTITUBE permits greater working pressures and higher operating temperatures than those recommended for polyethylene tubing. The tubes have outstanding impact and abrasion resistance, coupled with unusually high fatigue resistance to flexural and vibrational stresses over a broad temperature range. The tubing is resistant to most chemicals and solvents.

CRESCENT NYLON MULTITUBE is available with 2 to 37 tubes, protected against mechanical injury by a flexible, interlocked, galvanized steel, aluminum or bronze armor. A polyvinyl chloride (PVC) sheath, or a combination of both can be furnished when additional corrosion protection is required. Each tube is individually numbered throughout the length for positive identification of all tubes at any point.

THREE STANDARD TYPES TO MEET YOUR SPECIFIC NEED

TYPE NA— Interlocked, galvanized steel armor provides complete mechanical protection to the inherently corrosion-resistant tubing. Also available with aluminum or bronze armor.

TYPE NAT— Polyvinyl chloride (PVC) sheath over the armor adds corrosion protection for the armor. Can be buried in the earth.

TYPE NT— PVC sheath gives limited mechanical protection. For use in troughs, trays or conduit.

CRESCENT NYLON PRECISION INSTRUMENT TUBING, TYPE N,
is also available in 100-foot coils in cartons
and 500-foot lengths on spools.

SEE OUR BOOTH NO. 427 AT I.S.A. SHOW

CRESCENT INSULATED WIRE & CABLE CO., INC.

TRENTON, NEW JERSEY

CIRCLE 120 ON READER-SERVICE CARD

NEW...
PYRO-EYE*
Two-Color Optical Pyrometer

provides

fully automatic temperature measurement, recording and control in the ranges from 750°C to 2500°C and 1400°F to 4500°F.

Pyro-Eye is designed for in-plant and laboratory temperature measurement of incandescent molten metal, glass, ceramics, billets, rods, sheets, refractories and many other high temperature applications.

Continuous, automatic measurement and control of high temperatures is now possible because Pyro-Eye provides a high degree of repeatability and accuracy.

Pyro-Eye is accurate because it is relatively unaffected by unknown or variable emissivity. It measures temperature as a function of spectral characteristics . . . not as a function of total radiation.

*Trade Mark of Instrument Development Laboratories, Inc.

Get full details . . .
See PYRO-EYE in Booth 1603
15th Annual ISA Exhibit
N. Y. C. Coliseum, Sept. 26-30
or write

INSTRUMENT DEVELOPMENT LABORATORIES, INC.
Subsidiary of ROYAL McBEE
67 MECHANIC STREET, ATTLEBORO, MASS., U. S. A.

CIRCLE 213 ON READER-SERVICE CARD

PRESSURE CONTROLLER

New Pressure Controller, Type PSC-2, consists of an integrated system which combines an adjustable, highly-sensitive mechanical pressure regulator to the desired pressure and compensates for any subsequent drift. A continuous and independent indication of the pressure maintained is provided by the Photo Scanner null indicator. Offered in two ranges: 0.5" to 40" Hg (−3000 ft to +100,000 ft) for calibration of altimeters, or 0.8" to 105" Hg for calibration of airspeed indicators, Machmeters, air data computers, and other impact pressure devices. Established pressure is maintained within 0.0005" Hg or less. Bulletin contains details.—*Hass Instrument Corp., 6173 Branch Ave., Washington 23, D. C.*

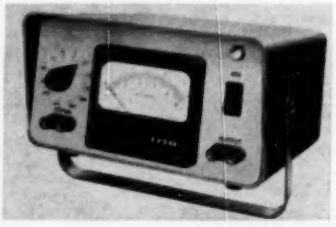
CIRCLE 284 ON READER-SERVICE CARD

VIBRATION TESTER

New "Optical Wedge" is a pressure-sensitive wedge-shaped sticker that can be affixed to a flat surface on the object under test. As the wedge vibrates with the piece under test, two triangles will appear. Available in limited quantity and without charge from national sales representatives.—*MB Electronics, 781 Whalley Ave., New Haven 8, Conn.*

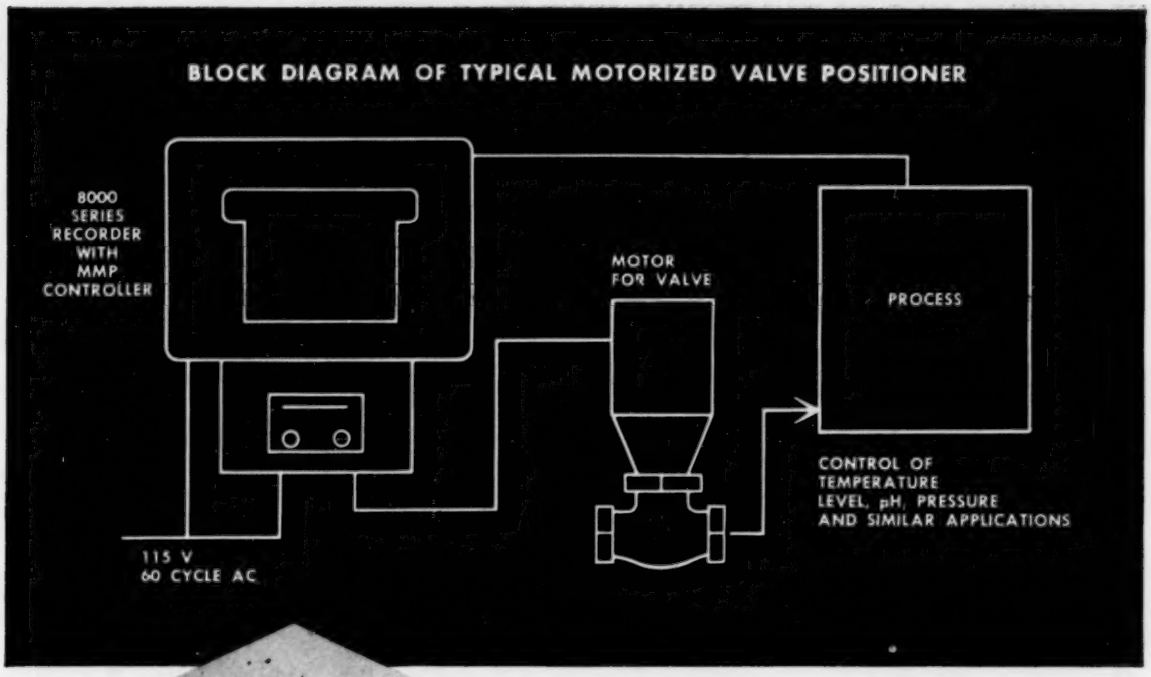
CIRCLE 285 ON READER-SERVICE CARD

PORTABLE AC VTVM



New portable Vacuum-Tube Voltmeter measures a-c voltages above ground, capable of reading as low as 20 μv on its 1 Mv range. Publication 60-120 gives details.—*Trio Labs., Inc., Plainview, L. I., N. Y.*

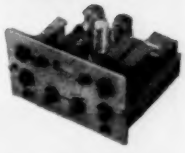
CIRCLE 286 ON READER-SERVICE CARD


BLOCK DIAGRAM OF TYPICAL MOTORIZED VALVE POSITIONER
8000 SERIES RECORDER WITH MMP CONTROLLER
MOTOR FOR VALVE
PROCESS
CONTROL OF TEMPERATURE LEVEL, pH, PRESSURE AND SIMILAR APPLICATIONS
115 V 60 CYCLE AC

Wheelco . . . for flexibility in process control applications

Wheelco indicating-recording-controllers offer you utmost applications flexibility with top-quality process control instrumentation for measurement, indication, control and permanent recording of motion, flow, temperatures, speed, strain, hydrogen ion (pH) and other variables which can be resolved into electrical signals. Constant research, skilled engineering, precision manufacturing and efficient service are the qualities that have built Wheelco leadership . . . industry-wide applications have proved it . . . a nationwide network of trained service engineers insures it. Contact your nearby Wheelco sales and service personnel for complete information. They are at your disposal.

8000 SERIES single point indicating-recording-controllers and multipoint recorders. Bulletin F-8616-2, single point; F-7955-1, multi-point.



MM SERIES CONTROLLERS. Three function controllers; MMP position type, MMC current output type, and MMD duration type. Magnetic modulated. Adaptable to varied control needs. Bulletin F-8726, MMC; F-8727, MMP; F-8745, MMD.

2000 SERIES recorders and recorder-controllers. 4⅝" width on 12" diameter chart. Bulletin F-8939.

THE MARK OF QUALITY

BARBER COLMAN

Wheelco Instruments Division

BARBER-COLMAN COMPANY

Dept. H, 1515 Rock Street, Rockford, Illinois, U.S.A.

BARBER-COLMAN of CANADA, Ltd., Dept. H, Toronto & Montreal. Export Agent: Ad. Auriema, Inc. N.Y.

CIRCLE 121 ON READER-SERVICE CARD

A NEW ADDITION to MERCOID PRESSURE CONTROLS

316 STAINLESS STEEL

Welded Bourdon Tube and Pressure Connection

Series D-41, 243, 541

316 stainless steel welded Bourdon tube. ¼" (316) stainless steel pressure connection. Nickel plated mechanism. Outside adjustments. Calibrated dial. Hermetically sealed mercury contact.

Operating ranges: 30" vac.-75 psig; 10-100 psig; 30-400 psig; 75-800 psig. and 100-1000 psig.— with varying differentials and electrical capacity to meet your application.

Three case styles: General Purpose NEMA 1; Weather-Proof NEMA 1A, 2, 3, 4; Explosion-Proof Class 1 Group C, & D; Class 2 Group E, F, G, NEMA 7, 9, 9A.

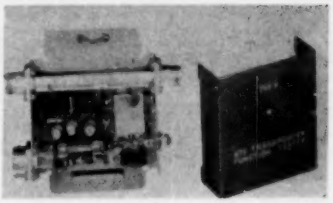
WRITE FOR BULLETIN 019

THE MERCOID CORPORATION
4211 Belmont Ave., Chicago 41, Ill.

CIRCLE 122 ON READER-SERVICE CARD

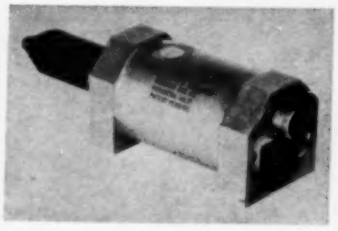
DC PRESSURE TRANSDUCER

New Transponder Function Tester, Model 758, provides two valuable features: (1) a panel light informs the pilot when his transponder is being interrogated during flight, and (2) by use of a switch, either on the ground or in the air, the pilot is informed of the operating condition of the transponder. Details in bulletin.—*Wilcox Electric Co., Inc., Fourteenth and Chestnut, Kansas City 27, Mo.*



CIRCLE 287 ON READER-SERVICE CARD

PRESSURE TRANSDUCER

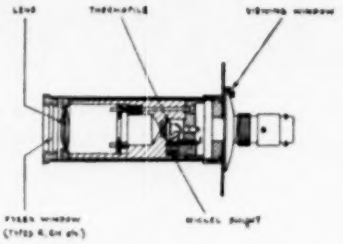


New Pressure Transducer, Model P2-1253, functions on specific portions of range; e.g., 475 to 550 psi with full 0—5 vdc output. Features include: high output—no amplification needed; exceptional resistance to acceleration and vibration; no friction effects; constant output impedance and continuous resolution. Accuracy: combined linearity and hysteresis—better than 0.15% of pressure.—*Wiancko Engineering Co., 255 N. Halstead, Pasadena, Calif.*

CIRCLE 288 ON READER-SERVICE CARD

RADIATION PYROMETER

New West-Land Radiation Pyrometer for furnaces and kilns with temperatures of 1400°F to 6000°F and high-temperature baths of "problem" liquids, provides continuous and accurate direct readings without requiring attention so long as the target area exceeds minimal standards. Can be used with any of the West line of millivoltmeter controllers or indicators or potentiometric instruments.—*West Instrument Corp., 4363 W. Montrose Ave., Chicago 41, Ill.*



CIRCLE 289 ON READER-SERVICE CARD

PEAK FOLLOWING AMPLIFIER

New Model V63 Peak Following Amplifier, used to amplify signals from crystal-type accelerometers, has the unique feature that it produces a proportional d-c level for each peak of acceleration. When the d-c output level exceeds the reference voltage, a relay becomes energized which can be used to shut down the test, or sound an alarm, before the test becomes destructive. Output is up to 100 ma, which makes it possible to drive high-frequency recorders.—*Video Instruments Co., Inc., 3002 Pennsylvania Ave., Santa Monica, Calif.*

CIRCLE 290 ON READER-SERVICE CARD

. . . her conscientious workmanship watches over

RECORDING CHART RELIABILITY

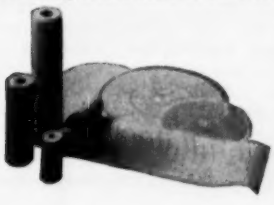
"Dish" occurs at the core end of a roll chart wound with incorrect tension. It means loose winding — and can lead to trouble.

Lois Deinhart, one of GC's experienced rewind operators, helps prevent this trouble from ever occurring. Here she is operating one of a battery of high speed precision rewind machines that roll strip charts to the exact length and tension required. Inspection by Lois and other skilled operators allows only perfect rolls to pass for shipment.

Because of special equipment and specially talented people, GC has become the world's largest manufacturer of recording charts—producing rolls, for instance, for virtually every make of strip chart recording instrument on the market. Over 70 different types of cores are available, each suited to the requirements of a specific instrument. End of roll indicators can be provided for visual, mechanical or electronic alarms.

GC's stock catalog lists over 15,000 different types of circular, strip and rectangular charts. We also design and produce special purpose charts to fit your most exacting needs.

More than 5,000 chart users have come to rely on GC Recording Charts for accurate, dependable performance—chart after chart—year after year. In fact, GC Charts must be good to sell so well for so long. Try them yourself ! Let us send you our complete 1960 Stock List, and sample charts for one of your instruments.



RECORDING CHARTS

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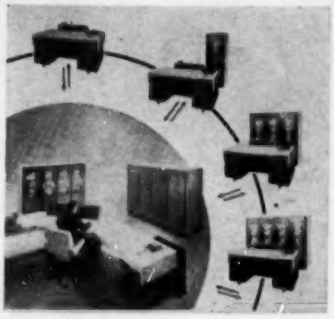
CIRCLE 123 ON READER-SERVICE CARD

SATELLITE COMPUTERS

New Satellite Computer System employs Control Data's large-scale 1604 Computer and the desk size 160 Computer. The 160 Computers are used in small, independently directed data processing centers that have direct access to the large-scale 1604. Thus various departments in a company can each operate a 160 Computer in its own center and at any time interrupt the 1604 and transmit data to the large computer at the rate of 160,000 characters/sec. *Control Data Corp., 501 Park Ave., Minneapolis 15, Minn.*



CIRCLE 291 ON READER-SERVICE CARD

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Wherever the specific gravity of liquid products or processing fluids is an important factor Arcco-Anubis Liquid Gravitometers will render accurate recordings of contiauous flow and spot checks of samples under varying conditions of temperature and pressure. Foreign liquids and gases are automatically purged. Changes in the specific gravity of the sample are recorded almost instantly. High pressure and high viscosity liquids are handled with ease. Charts graduated for specific gravity are available in over 100 ranges. Charts for Degrees A.P.I. are available in over 30 different ranges. Arcco Liquid Gravitometers are made for recording, controlling, indicating, transmitting and various combinations of these functions. Special charts when required can be furnished at slight additional cost.
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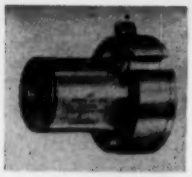
CIRCLE 124 ON READER-SERVICE CARD

LINEAR ACCELEROMETER



New Linear Accelerometer, Series A65, whose size and light weight make it ideally suited for in-flight instrumentation applications, responds flat within ±5% from static to 830 cps. Embodying Statham's unbonded-strain-gage principle, with the resistive elements arranged in a complete Wheatstone bridge, it provides the accuracy, reliability and long service life characteristic of this gage. Model variations are available in a wide range from ±7.5g to ±150g. Requiring an excitation of 5v dc or ac, the new accelerometer has a nominal output of ±20 mv. Its combined nonlinearity and hysteresis is less than ±1% of full-scale output.—*Statham Instruments, Inc., 12401 Olympic Blvd., Los Angeles 64, Calif.*

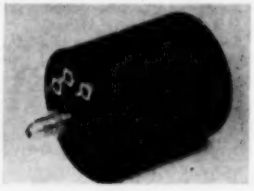
CIRCLE 292 ON READER-SERVICE CARD

MINIATURE PICKUPS

New sub-miniature Pickups, developed as monitoring devices for automation and production applications, are adapted for use with the company's miniature relay control amplifiers, which provide adjustable controls for both sensitivity and light strength. In addition to reduction in size, the units can be standardized on a wide range of applications.—*Photomation, Inc., 96 South Washington Ave., Bergenfield, N. J.*

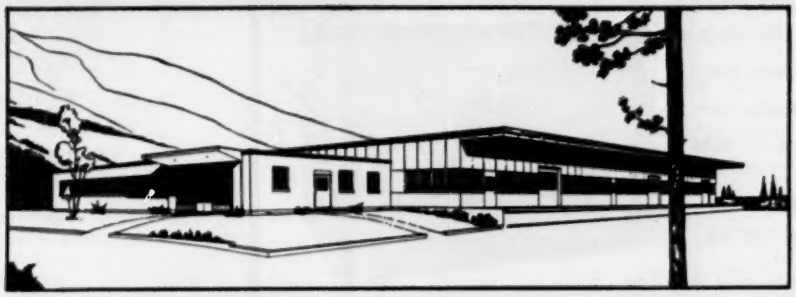
CIRCLE 293 ON READER-SERVICE CARD

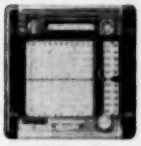
HI-OVERPRESS TRANSDUCERS



New series of Transducers ranging from 0-25 to 0-300 psi, that can withstand overpressures of 1500 psig, features a sensor design that requires no auxiliary cut off valving arrangement. Model 101 (illustrated) has an internal structure ideally suited for differential-pressure-measurement applications involving the introduction of high pressures both to the sensor and the instrument case. Available with potentiometric outputs.—*White Avionics Corp., Terminal Rd., Plainview, L. I., N. Y.*

CIRCLE 294 ON READER-SERVICE CARD





NEW HOME FOR SWARTWOUT AUTRONIC® CONTROLS. INDUSTRY'S FIRST AND "OLDEST" FULLY ELECTRONIC CONTROL SYSTEMS NOW COME TO YOU FROM THE NEWEST INSTRUMENT PLANT IN THE COUNTRY. Expanded facilities. Improved manufacturing techniques. Computer-automated production and inventory control. These and other recently instituted efficiencies have pushed Autronic production to record levels in record time. Our field engineering staff has been enlarged, too. Service is better all the way around. Now, more than ever before, Swartwout is the leader in electronic process instrumentation.

SWARTWOUT

SWARTWOUT DIVISION, CRANE CO.

Hooksett Industrial Park, Manchester, New Hampshire

CRANE

CIRCLE 125 ON READER-SERVICE CARD

POST ELECTRONIC PRODUCTS

Keeps tabs on hourly production and count . . . too!

MODEL P2 RM

The Post P2 RM is a preset electronic counter which **also indicates hourly production rate** on a two-scale rate meter. By using this dependable component in conjunction with sheet fed machines, conveyor lines, small parts manufacturing, etc., you have the benefit of "batch" counting desired quantities. At the same time you'll be able to keep tabs on your production flow. A visual totalizer indicates unit or total batch counts.

For complete details write: Decitron

POST ELECTRONIC PRODUCTS

Division of Reid Brothers Company, Inc.

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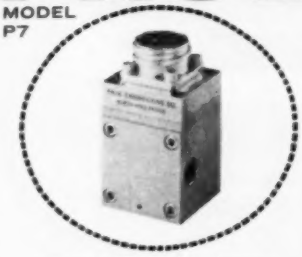
PACE

MODEL P7



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PRESSURE TRANSDUCER

Ranges: 0.1 to 500 psi — Gage or Differential.

Pressure Media: Corrosive liquids or gases, both sides.

Withstands Extreme Overpressure.

High Natural Frequency for dynamic response.

PACE's Model P7 Transducers are designed for low and medium pressure measurements of laboratory accuracy in aircraft and missile flight and ground test applications.

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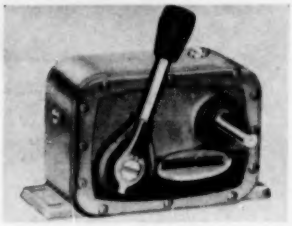
VARIABLE SPEED DRIVES



New 400-Series stepless Variable Speed Drives have built-in safety disconnect and a new control for fast and precise speed setting. Other features include a larger input shaft on the smaller models; wider mounting pads; double slotted holes for greater stability and easier alignment; up to 40% decrease in heat rise over ambient; improved gasketing and oil seals and non-heat-conducting control knobs. Lubricant is shipped with each unit. Stable drive with constant torques from 3 to 450 in-lb is provided.—*Zero-Max Co.*, 1904 *Lyndale Ave., South, Minneapolis 5, Minn.*

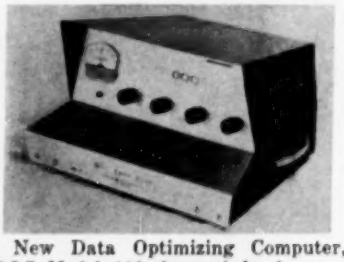
CIRCLE 295 ON READER-SERVICE CARD

SILICONE EXTRUDED TUBING

New Flexite SR Silicone Rubber Extruded Tubing which exhibits outstanding flexibility, retaining elasticity after long exposure to temperatures from −85°C to 225°C, features excellent tensile strength, elongation and tear strength resistance to corona, oils and weathering. It withstands short term temperatures to 315°C, and is rated for continuous use at 200°C.—*L. Frank Markel & Sons, Norristown, Penna.*

CIRCLE 296 ON READER-SERVICE CARD

DATA OPTIMIZING COMPUTER



New Data Optimizing Computer, DOC Model 190, is needed wherever there is repetitious use of a calibration curve. Any electrical instrument producing an output which must be converted, by referring to the instrument's calibration curve, can be connected compatibly to the computer. An example of its use is with temperature-reading devices which employ a thermistor as the detector. The output of the thermistor is non-linear. Records taken from such a device must be corrected by reference to the device's calibration curve. Details in specification sheet.—*Custom Engineering & Development Co.*, 2647-49 *Locust St., St. Louis 3, Mo.*

CIRCLE 297 ON READER-SERVICE CARD

3 new instruments for process control

MV-1 POTENTIOMETER

For testing, calibrating or servicing newest process controllers and amplifiers which convert millivolt input signals into proportional currents for control or telemetering. Combines all functions of precision potentiometer, millivolt source and milliammeter. 1/10 of 1% accuracy. 5⅛" x 8" x 5⅜". 5½ lbs.

THE AUTOCOMP 1

For instrument checking and thermocouple measuring. Gives automatic cold junction compensation to devices used for measuring or controlling with thermocouples. Exclusive circuit employs thermistor network to match non-linear characteristics of thermocouples with output characteristics of bridge. 5⅛" x 8" x 5⅜". 6 lbs.

RU-1 "RUN UP" SOURCE

Combination millivolt and milliampere "run up" source for instrument calibration. Checks newest process controllers and amplifiers. Current source furnished by two self-contained 90V batteries made to give stable, uniform outputs with cold cathode type voltage regulator tube. Self-contained. 5⅛" x 8" x 5⅜". 10 lbs.

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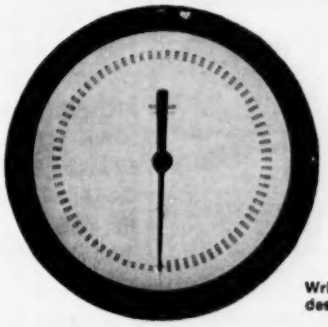

Designed for the Ultimate in Accurate Pressure Measurement

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Consider These Advantages:

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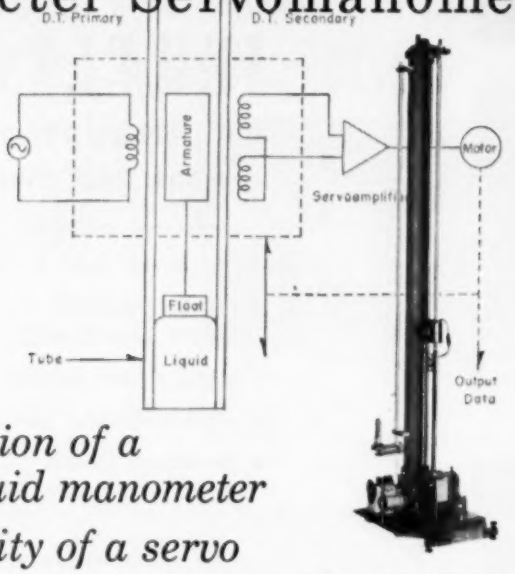
CIRCLE 132 ON READER-SERVICE CARD

Exactel Servomanometers



precision of a liquid manometer

...utility of a servo

Illustrated is Exactel Servomanometer Model C560IN-D with 60 inch range. Analog Temperature Compensation and digital output with synchro transmitter. Servomanometers are available in single or dual construction with five ranges to 120 inches and 25 optional features. The instruments are operational in nature and have been proven in a wide range of applications to combine exceptional accuracy, simplicity and the reliability required for industrial installation. Exactel's sixteen page Bulletin 500 describing new Servomanometer techniques and many new applications is available on request.

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INSULATION TESTERS

GENERATOR TYPES

MINOR—Dwarf Size
500V, 100 Megohms

MAJOR—Small Size
Constant Voltage 500V
Megohm & Ohm Scales

STANDARD—Heavy Duty
500/1000V
up to 2000 Megs.

BATTERY VIBRATOR TYPES

NON-CRANKING

MODEL B-6—0-200 Megs.
2000 Ohms, AC-D.C. Volts

MODEL B-7—20/200 Megs.
200/20,000 Ohms.

PLUG IN TYPE

MODEL P-1 for PRODUCTION TESTING
115V AC line operated
500/1000V
100/1000/2000 Megohms

ELECTRONIC TYPE

20,000,000 Megohms

MODEL 29A with 11 ranges
Range 300,000 to 20,000,000 megohms
Test Potentials 85V/500V

Booth #2011 ISA
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SCLEROSCOPE
FOR TESTING THE HARDNESS OF METALS. PIONEER AMERICAN HARDNESS STANDARD. OVER 40,000 IN USE. (ASTM A427)

DUROMETER
FOR TESTING THE HARDNESS OF RUBBER & RUBBER-LIKE MATERIALS
(ASTM D676)
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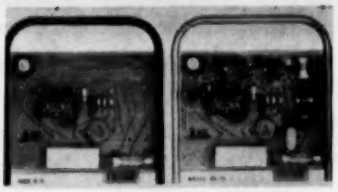
CIRCLE 135 ON READER-SERVICE CARD

DIGITAL MODULES



New Oscillator Clock, Model OC-10; and a Slave Clock, Model SC-10; in the series of dynamic, 1-Mc digital modules are for use in the recently announced Model BL-11. The oscillator clock has a crystal-controlled oscillator which provides 1-Mc clock pulses; the slave clock is identical to the OC-10, but without the crystal controlled oscillator.—*Computer Control Co., Inc., 983 Concord St., Framingham, Mass.*

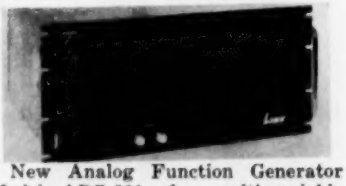
CIRCLE 298 ON READER-SERVICE CARD

WIDE-RANGE MICROMANOMETER

New Equibar Pressure Meter, an Electronic Micromanometer, has a very wide pressure range and fast speed of response. Eight full-scale ranges from 0.01 to 30 mm Hg can be selected by a front panel switch. In addition to visual readout, both phase-sensitive ac and polarized dc electrical outputs are provided.—*Trans-Sonics, Inc., Burlington, Mass.*

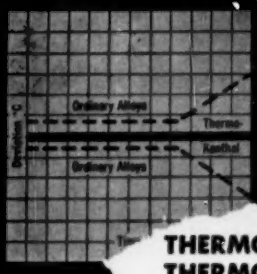
CIRCLE 299 ON READER-SERVICE CARD

FUNCTION GENERATOR



New Analog Function Generator Model APG-201, for multi-variable open- or closed-loop functions utilizes a translatory servomotor operated by a solid-state servo amplifier and a unique ceramic film resistance block, which serves as an analog memory and interpolation element. Overall system accuracy is better than 1% and frequency response is more than 5 cps over full scale.—*Link Div., General Precision, Inc., Binghamton, N. Y.*

CIRCLE 300 ON READER-SERVICE CARD



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Thermo-Kanthal is a product of world recognized Kanthal leadership in special purpose resistance and heating alloys. It is specifically designed to combat the problem of stability with age and use. Particular attention to the composition of the negative leg has resulted in a new order of accuracy and stability, particularly in the 1800°F to 2300°F range.

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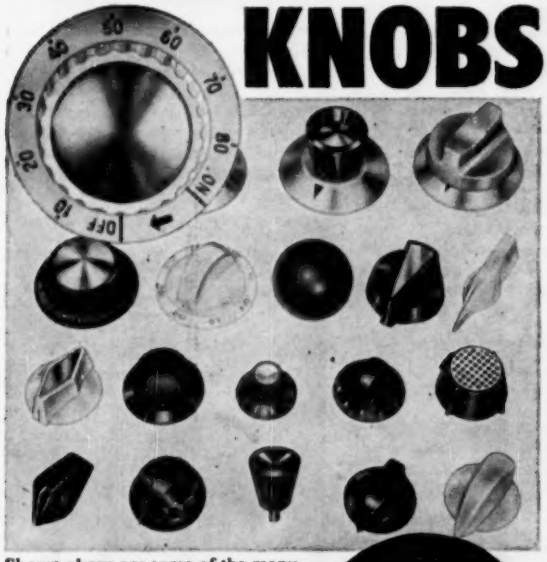

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Shown above are some of the many Rogan knobs available from stock molds. Fast delivery. Special shaft holes at nominal cost. Send for details and catalog.

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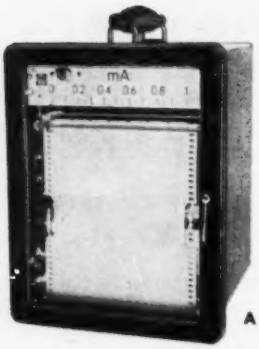

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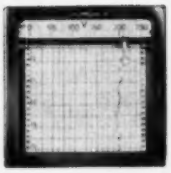

B

CURTISS WRIGHT

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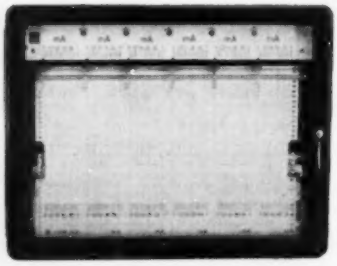

C

1. Moving-Coil and Dynamometer Movements—No choppers, tubes, motors, slidewires, mirrors . . . provides utmost reliability. AC, DC, and Power movements.

2. Up to 6 Channels Available—Curtiss-Wright Double Size Models are the only Rectilinear Strip Chart Recorders to offer up to 6 channels. Curtiss-Wright recorders provide simultaneous recording of 2 to 6 variables on a single chart in any combination of different types of movements.

3. Sensitivity Down to 250 UA for DC . . . can be extended beyond 250 ua by DC amplifier (optional).

4. Accuracy 1% for Moving-Coil Recorders—Conservatively rated as ±1% of full scale for DC movements. Unusually low friction of pen against chart.

5. Inkless and Ink Recording—Inkless recording is standard equipment on all but Miniature Models, on which it is optional. Cleanest, easiest method . . . a fine metal stylus "burns" the record into zinc coated chart paper. Instantly converted to ink recording.

6. Rectilinear Recording—A patented mechanical linkage changes angular motion of the needle into a straight line, giving an undistorted picture of the signal. Avoids errors, saves time.

7. Three-Speed Transmission—plus 60:1 speed changes from hours to minutes provides 6 interchangeable speeds in all.

8. Motor and Spring Drives—Sync motor, hand-wound short drive or electrically wound spring motors. Automatic chart rewind.

9. Light and Compact Design—Small size and advanced design engineering of movement allows space and weight savings.

10. Dust-proof and Splash-proof Cases—Steel cases decrease effect of stray magnetic fields.

11. Shock-proof Movement—Extra reliability when used in portable applications.

12. Outstanding Workmanship—Improved design and meticulous attention to detail assure highest quality precision performance. All Curtiss-Wright recorders carry a 1-year guarantee.

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A. Standard Models. 81 (portable) and 82 (flush). Weight: 19 lbs. 7½" x 9⅞" x 8½". $445.00.

B. Miniature Square Model. (85). Weight: 16 lbs. 5⅞" square, 12¾" deep. $330.00 and up.

C. Double-Size Models. 83 (portable) and 84 (flush). Weight: 26 lbs. 12¾" x 9 13/16" x 8¾". $860.00 and up.

Curtiss-Wright offers you time-proven advantages in precision operation. These Rectilinear Strip Chart Recorders combine advanced design with highest quality workmanship. Moderate in price, these fine precision instruments are rugged and reliable, simple to operate. Write for complete information.

PRINCETON DIVISION

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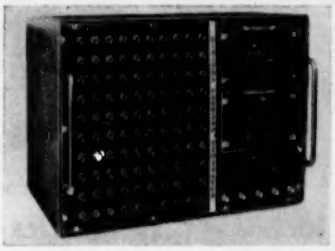
CORPORATION • P.O. BOX 110, PRINCETON, NEW JERSEY

CIRCLE 140 ON READER-SERVICE CARD

DIGITAL PATTERN GENERATOR



New transistorized modular Digital Pattern Generator provides a simulated and flexible time-division-pattern output for testing and development of a wide range of computers and communications systems. Unit features an adjustable pattern length from 1 to 100 bits with the state of each bit independently controlled as to "1" or "0" from the front panel.—*Magnavox Co., Government and Industrial Div., Fort Wayne, Ind.*

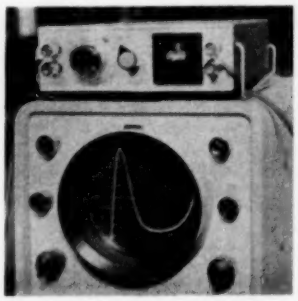
CIRCLE 301 ON READER-SERVICE CARD

ELAPSED TIME INDICATOR

New Running-time Indicators, Series 5700, have a range of 99,999.9 hours (minutes available on request) with a minimum time indication of 1/10 hour. Six display wheels, black numerals on white nylon, show elapsed time. Low cost is stressed.—*Automatic Timing & Controls, Inc., King of Prussia, Penna.*

CIRCLE 302 ON READER-SERVICE CARD

CURVE TRACER



New Tunnel Diode Curve Tracer permits study of forward characteristics of tunnel diodes made by various manufacturers, including Texas Inst.'s gallium arsenide. Any sensitive oscilloscope can be used to create current and voltage wave forms.—*Texas Instruments Inc., 3609 Buffalo Speedway, Houston 6, Tex.*

CIRCLE 303 ON READER-SERVICE CARD

● ELIMINATE DELAYS!

● KEEP YOUR OPERATING COSTS WHERE THEY SHOULD BE!

PORTABLE 40-POUND BENCH MODEL 106

Here is a speedy, economical 2 or 3-dimensional engraver used by thousands of dollar-conscious companies. It features 5 positive, accurate pantographic ratios; ball bearing spindle with 3 speeds up to 14,000 rpm. Is supplied with one copy carrier that accepts all standard master type sizes. Will actually work up to 10" by any width. Height of pantograph and position of cutter are continuously adjustable.

You Make Your Own Engraved Nameplates!

MODEL D-2 HEAVY-DUTY 2-DIMENSIONAL

Pantograph for milling, drilling and engraving.

Vertical adjustment of copy table automatic with Pantograph. Features: unobstructed on 3 sides to take large work; micrometer adjustment for depth of cut; ball bearing construction throughout; spindle speeds up to 26,000 rpm for engraving or machining; vertical range over 10"; ratios 2 to 1 to infinity — master copy area 26" x 10"

NEW MODEL D2-201 PNEUMATIC ATTACHMENT

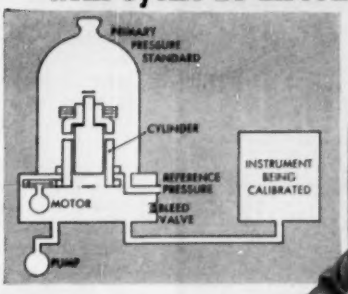
for use with Model D2 Pantograph Engraver to rapidly drill holes in printed circuits by tracing templates. Drills as many as 100 holes per minute. Equipped with foot switch; spindle air cylinder; regulating valve and pressure gauge; filter and oiler. It's ready to use as soon as it's attached to an air compressor

Write or call for full details and prices.

GREEN INSTRUMENT COMPANY, INC.
Dept. 86 295 Vassar St
Cambridge 39 Mass. Tel. Eliot 4-7989

CIRCLE 141 ON READER-SERVICE CARD

NEW! PRIMARY PRESSURE STANDARD with Cyclic Bi-directional Rotation



Now you can calibrate any pressure measuring instrument from 0.2 psi absolute to 500.0 psi gauge with an accuracy of 0.015% of reading!

- Exclusive cyclic bi-directional rotation of cylinder minimizes lift error
- Four pressure ranges
- Use any reference pressure from zero to one atmosphere absolute
- Self-contained pressure source provides pressure up to 15 psi

Write for Technical Bulletin on Primary Pressure Standard.

DYNAMETRICS CORPORATION

Northwest Industrial Park, Dept. 18, Burlington, Mass.

CIRCLE 143 ON READER-SERVICE CARD

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BARIUM TITANATE
BISMUTH
BRASS
CARBORUNDUM
CERAMIC
COBALT FERRITE
COPPER
*CORNING 707
*CORNING 7052
COPROUS BROMIDE
FERRITE
FERROX
**FLUORIDE, CALCIUM
**FLUORIDE, LITHIUM
GALLIUM ANTIMONIDE
GALLIUM ARSENIDE
GARNET
GERMANIUM
GOLD
INDIUM ANTIMONITE
INDIUM PHOSPHIDE
INDOX
IRON SINGLE CRYSTAL
LITHIUM
MAGNETIC PLUMBITE
MELAMINE FIBER GLASS
MICA, SYNTHETIC
NICKEL OXIDE
PLATINUM
POTASSIUM BROMIDE
*PYREX
*QUARTZ, CRYSTAL
*QUARTZ, FUSED
**SAPPHIRE
**SODIUM CHLORIDE
**STEEL
STRONTIUM TITANATE
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ALL TYPES KNOWN GLASS

* Carried in stock
** Purchased for orders

CIRCLE 142 ON READER-SERVICE CARD

TYPE M

Solenoid Valves

"We've actually improved quality and radically lowered prices. Compare!"

TYPICAL USER NET PRICES F.O.B. FACTORY

SIZE	1 to 5	100 to 499
½"	$15.40	$11.15
¾"	18.50	13.60
1"	24.25	18.50
1½"	48.00	42.40

PRESSURES TO 400 psi

Packless • 2-Way • General Service • Normally Closed

Sizes ⅜" to 3" • Temperatures to 250° • Molded epoxy resin waterproof coils • Unbreakable piston rings • Self-cleaning • Guided valve seats • Simple, rugged construction. Only 2 moving parts • No diaphragms or linkages • Cushioned closing. No damaging hammer • Easy-off "O" ring bonnet construction in sizes ⅜" thru ¾" • High temperature coils and explosion proof housings at slight extra cost. Immediate delivery. Ask for Bulletin 600-M.

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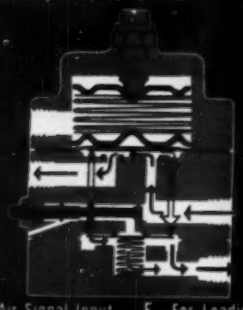
INDIANAPOLIS 18, IND.

GOULD SOLENOID VALVES — VELVETROL

CIRCLE 144 ON READER-SERVICE CARD

PACKAGED
pneumatic
CONTROL
automatic or manual
trip or reset = "MITE"

The "MITE" is a snap-acting, adjustable pneumatic switch and/or relay.
Venting, lock-up and switching are accomplished as follows:



A – Air Signal Input
B – Signal Output (Lock-up on trip)
C – Signal Output (Vent on trip)
D – Remote Pneumatic Trip
E – Remote Pneumatic Reset
F – For Loading to Nullify "E"
G – TRIP TO OPEN (To "H")
H – Common to "G" and "I"
I – TRIP TO CLOSE

Get complete details on the "MITE" Series today

GEORGE W.
DAHL
COMPANY, INC.
86 TUPELO STREET
BRISTOL, RHODE ISLAND
Clifford 3-9500

VALVES AND CONTROLS FOR THE COMMUNICATIONS, PROCESS, AIRCRAFT AND MARINE INDUSTRIES

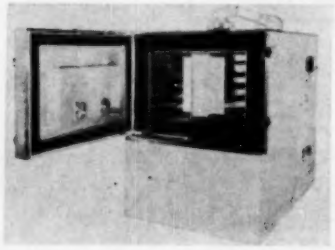
CIRCLE 145 ON READER-SERVICE CARD

GRAVITOMETER

New Sinclair-Cenco Gravitometer which can be used to blend crude oil products or a variety of other liquids to a constant outgoing gravity, operates by continuously taking a small sample of liquid product from a pipeline and pumping it through a column of fixed dimensions. As the sample flows through the column it is continuously weighed by means of a differential pressure transducer. The transducer, which is an unbonded strain gage, translates the weight of the sample into an electrical signal which can be directed to the input of an externally located redorder or to a valve controlling mechanism, or to both simultaneously.—*Central Scientific Co.*, 1700 *Irving Park Rd., Chicago* 13, *Ill.*

CIRCLE 304 ON READER-SERVICE CARD

TEMP SHOCK CHAMBER

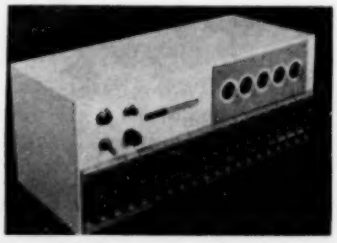


New Temperature Shock Chamber is a completely self-contained unit. Switching from hot to cold, in a temperature range of −85° to 425°F takes only 10 sec, and recovery time to the set point takes only 20 min. The entire operation is controlled with an automatic programmer.—*Tenney Engineering, Inc.*, 1090 *Springfield Rd., Union, N. J.*

CIRCLE 305 ON READER-SERVICE CARD

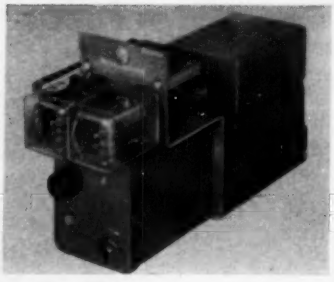
TIMING SYSTEM

New Central Timing System is basically constructed of a completely compatible set of modular units. The heart of the system is the Time Correlation Unit which consists of a time indicator, frequency divider, and time accumulator. System is designed to drive up to three remote time indicators. Bulletin contains details.—*Temco Aircraft Corp., Temco Electronics Div., Box* 6191, *Dallas* 22, *Tex.*



CIRCLE 306 ON READER-SERVICE CARD

TONE SIGNALLING SYSTEMS



New transistorized frequency-shift Tone Signalling System which provides data communications by means of shifting the frequency of a transmitted carrier, as opposed to the on/off mode employed in straight tone signalling, features the ability to carry three frequencies per channel. These are referred to as Mark, Space, and Neutral frequencies. Equipment is also available in Mark-Space models for high-speed keying and teletype operations.—*Hammarlund Mfg. Co., Inc.*, 460 *West* 34*th St., New York* 1, *N. Y.*

CIRCLE 307 ON READER-SERVICE CARD

Manufacturers–Reach more buyers and users of your measurement and control equipment, systems, and components—more often through—

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1961 BUYERS' GUIDE

Distribution—36,000 copies—to engineering management and technical personnel responsible for design, specification, purchase, application and maintenance of instruments, systems and devices for measurement, inspection, testing, analysis, computing, and automatic control.

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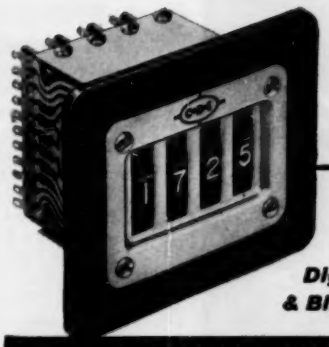
*1960 Guide (with only 9 months service under its belt) brought advertisers twice the leads of any previous edition!



C·D·I

Digital (Series TSD) & Binary (Series TSB)

NEW HIGHLY RELIABLE THUMBWHEEL SWITCHES

Available in permanent or removable wafers in 8, 10 or 12 positions up to 16 switches per modular assembly. Occupies only ¼" panel space per module. Variations available to special order.

Instant, easy numerical readout—only selected numbers are visible thru openings in the bezel plate. Thumbwheel is black molded nylon with ¼" engraved figures. Other colors available.

Construction is printed circuit wafers with silver, rhodium or gold laminate, precious metal alloy contacts and corrosion protected aluminum frame. Switch can be positioned horizontally or vertically.

Write for detailed specs today.

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PRECISION PRODUCTS DIVISION

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HARTMANN & BRAUN

MULTI-RANGE *Multavi*

VOLT-AMMETERS

for AC and DC

A Large Variety of Models and Ranges Available
Accuracy 1% for DC and 1.5% for AC

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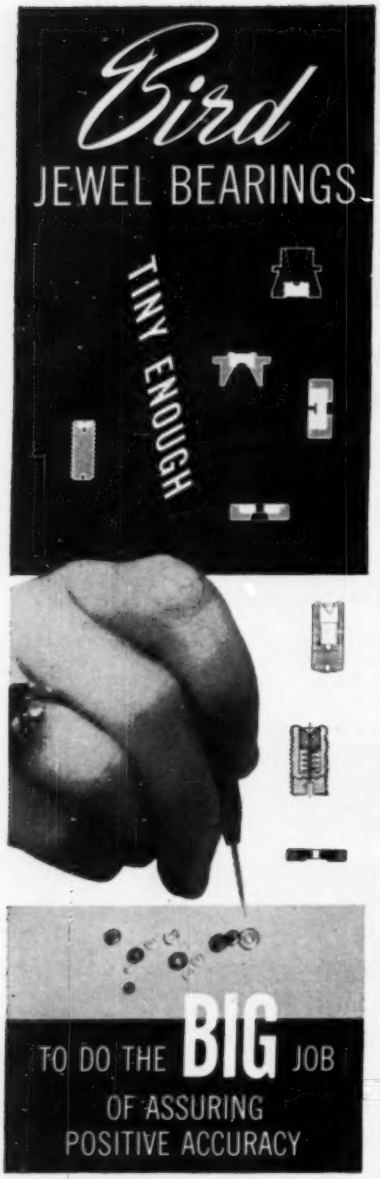
CIRCLE 147 ON READER-SERVICE CARD



Aircraft and electrical instruments, measuring and timing devices, testing and recording equipment — they all require the services of sub-miniature bearings that insure a fine degree of accuracy. Bird Precision Jewel Bearings fulfill this need because they are designed to provide peak accuracy in minimum space.

Available in a wide range of standard glass and sapphire types and sizes, including complete jewel assemblies and cushion jewel assemblies, Bird Jewel Bearings can save you money on your next design. Our engineering staff is at your service to aid you with your special requirements.

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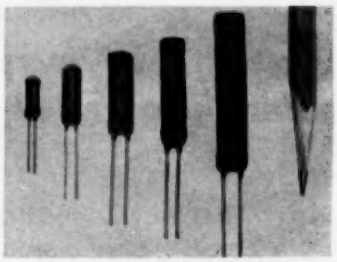
CIRCLE 149 ON READER-SERVICE CARD

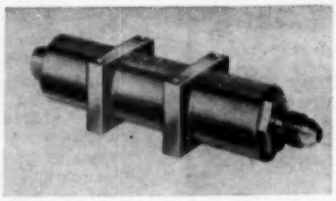
WIREWOUND RESISTORS

New Type PRS wirewound, miniature, precision Resistors which are base mounted with two parallel leads, meet power requirements in printed circuits. Their outstanding silicone coating maintains stable performance under adverse environmental conditions. Available in 4 wattages; 3, 5, 7 and 10; and in 5 sizes ranging from 9/16" x 3/16" to 1 25/32" x ⅜". Tolerance range is 0.05%, 0.1%, 0.25%, 0.5%, 1%, and 3%. Resistance range is from 0.05 ohm to 175K ohms.—*Dale Products, Inc., Columbus, Neb.*



CIRCLE 308 ON READER-SERVICE CARD

ABSOLUTE PRESS TRANSDUCER



Newly designed Transducers, Model H-73, covering the range between 0-800 and 0-5,000 psia, offer a total static error band of 1% (max) including linearity, hysterisis, resolution, repeatability, and friction; and a vibration error band of less than 1.75% at 35 G.—*Servonic Instruments, Inc., 640 Terminal Way, Costa Mesa, Calif.*

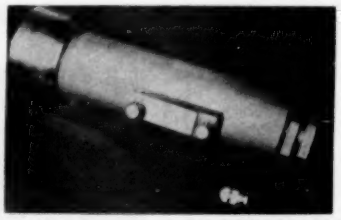
CIRCLE 309 ON READER-SERVICE CARD

STEPPING SWITCH

New Type ACS Stepping Switch for sequence controlling, counting and totalizing, scanning, information storage, and other switching operations can be furnished with 2, 3, 4, 8 or 12 single pole continuous rotation, for either shorting or non-shorting steps. Specification sheet gives details.—*Comar Electric Co., 3349 W. Addison St., Chicago 18, Ill.*

CIRCLE 310 ON READER-SERVICE CARD

PNEUMATIC REGULATOR



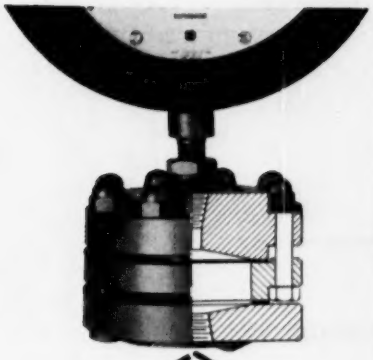
New Pneumatic Regulator for use with helium features operating pressure inlet: 100 to 20,000 psi; regulated pressure, using dome loading principle, adjustable from 100 to 20,000 psi; proof pressure: 40,000 psi. Flow rate to 100 lb/min helium with 6000 to 10,000 psi inlet pressure.—*Vinson Engineering & Sales Co., 8044 Woodley Ave., Van Nuys, Calif.*

CIRCLE 311 ON READER-SERVICE CARD

PORTABLE PRECISION METER

New portable Model 700 meter features sensitivities of 0.2 μamp, accuracy of better than ¼%, multiple (to 23) ranges, and special circuitry that enables the meter to withstand overload surges to 125,000,000% in some cases without impairment.—*Greibach Instruments Corp., 315 North Ave., New Rochelle, N. Y.*

CIRCLE 312 ON READER-SERVICE CARD



ONLY THE PRESSURE GETS THRU

Brookseals keep out clogging dirt and corrosive vapors.

A live diaphragm and an inert liquid fill do the job. Isolate the instrument, transmit the pressure.

Not a gasket anywhere. No O-rings, either. Instead: precisely honed metal-to-metal sealing surfaces.

Brookseals come in many different types, sizes and material specifications. There are models for pipe, flange and saddle mounting. Some are self-cleaning; others have integral flushing connections. Many are made to withstand overranges to 2500 psig.

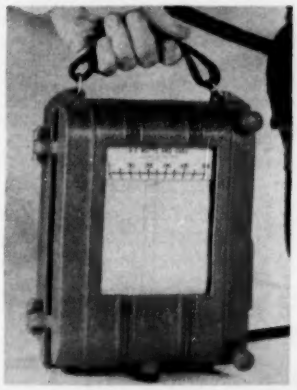
You can take them apart and put them together again in minutes—with just one ordinary wrench.

Bulletin 250 will give you more details.

BROOKS
ROTAMETER COMPANY
860 J Street
Lansdale • Pennsylvania

CIRCLE 150 ON READER-SERVICE CARD

PORTABLE RECORDER



New, portable hook-on Recorder, Type CF-8, that registers watts and vars on a single strip-chart, uses an inkless mechanism, taps its two records side by side (watts for 50 sec and vars for 10 sec) and features the fact that is can use a Type G-4 split-core current transformer that "hooks on" the line. Although a single-phase instrument, the recorder can also be used in polyphase circuits.—*General Electric Co., Schenectady 5, N. Y.*

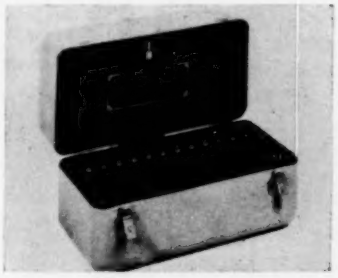
CIRCLE 313 ON READER-SERVICE CARD

IN-LINE RELIEF VALVE

New Series FRV Relief Valve is designed for use in pressure systems where a smooth, quiet, chatterproof operation is required, with zero leakage to within 95% of cracking pressure. Made of aluminum and stainless steel. Externally adjustable from 20 to 2000 psig. Available from stock in ¼", ⅜", and ½" male pipe and male tube sizes.—*Fisher Controls Inc., 1928 Lincoln Blvd., Santa Monica, Calif.*

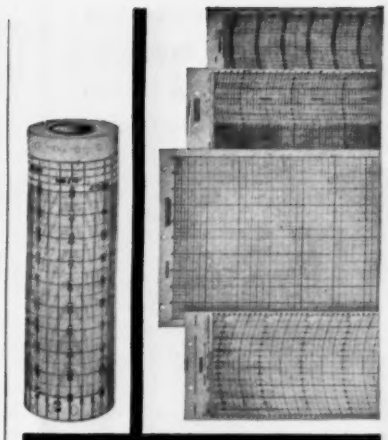
CIRCLE 314 ON READER-SERVICE CARD

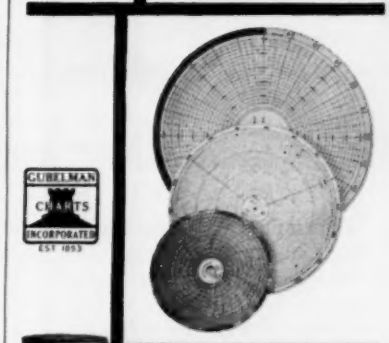
PORTABLE FUEL QUANTITY CALIBRATION UNIT



New Calibrating Unit for Fuel Quantity Gaging Systems, Model B511, contains 12 separate circuits and complete test harnesses. The completely self-contained unit is used primarily for checking gages on the DC-8 jet liners.—*Liquidometer Corp., 3616 Skillman Ave., Long Island City 1, N. Y.*

CIRCLE 315 ON READER-SERVICE CARD





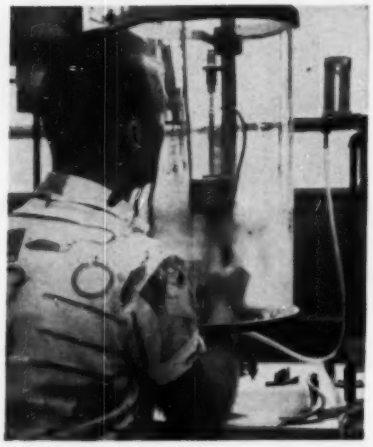
CHARTS
for Recording Instruments

We offer to the Instrument Maker Charts for all methods of Recording: Pen, Ball Point, Electrical, Thermal, Pressure and Metallic Stylus.

Precise quality control of materials, modern specialized equipment operated under controlled atmospheric humidity conditions by highly skilled and experienced personnel combine to produce Charts of uniformly high accuracy.

GUBELMAN
CHARTS INCORPORATED
100-6 E. KINNEY ST., NEWARK 5, N. J.

Varian protects hydrogen brazing operations with J-W gas detector



Construction of Varian Associates backward wave oscillator tube involves brazing two copper tubes with silver eutectic. In the operation shown an oxygen flame in a hydrogen atmosphere flows the eutectic.

Varian protects against a build-up of an explosive gas mixture in the shop with a J-W warning system. The indicating unit (model RV, shown at right) is situated in a central place and monitors nine work stations automatically at four minute intervals.

Varian's explosive gas detector system was designed to custom requirements. If you have an explosive gas hazard in your operations, contact Johnson-Williams for information on standard models and J-W engineering service on gas warning systems.

J-W **Johnson-Williams, Inc.**
Palo Alto 13, California

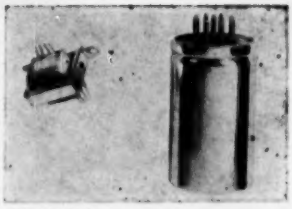
Leadership in explosion prevention since 1927

Canadian customers please write:
Safety Supply Co., Toronto, Ont.
Fleck Bros. Ltd., Vancouver, B. C.

CIRCLE 151 ON READER-SERVICE CARD

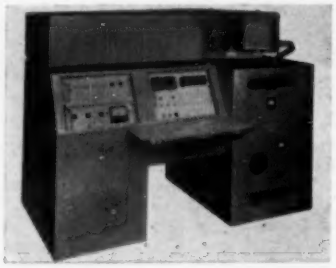
COMMERCIAL CHOPPER

New Chopper, Model C-1800, and associated Input/Output Transformer, Series A-1500, can be used as a null indicator, modulator or demodulator. It features low residual noise, coil voltage of 6.3 v ± 10% rms, and SPDT contact circuit.—*James Electronics Inc.*, 4050 *N. Rockwell St., Chicago* 18, *Ill.*



CIRCLE 316 ON READER-SERVICE CARD

COMPACT ATOMCOUNTER

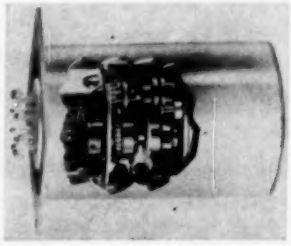


New Compact Atomcounter, a direct reading spectrometer, is of unitized self-contained construction and has characteristics, which equal the performance of the most elaborate direct readers commercially available. It can be purchased with either of two forms of read-out electronics: either 10 preselected elements in up to 30 elements in five alloy types or matrices, or 22 elements in up to 11 matrices or alloy types.—*Jarrell-Ash Co., 26 Farwell St., Newtonville* 60, *Mass.*

CIRCLE 317 ON READER-SERVICE CARD

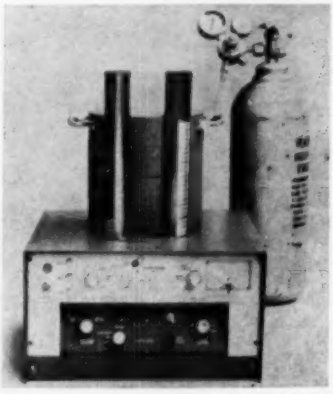
TIME DELAY TIMER

New Series "D" is a hermetically sealed automatic-reset Time Delay Timer specifically designed for applications requiring extreme accuracy and dependable service, operating under extreme ambient conditions. Qualified for MIL-T-4807, shock and vibration, methods 1A, 3A, and 5A. MIL-E-5272B, humidity, salt spray, high and low temperature, barometric pressure, and life test; conforms also to MIL SPEC. R-5757.—*Industrial Timer Corp.*, 1407 *McCarter Highway, Newark* 4, *N. J.*



CIRCLE 318 ON READER-SERVICE CARD

AUTOMATIC SAMPLE CHANGER



New automatic Counting System, Model C115, for beta-emitting solid radioactive samples is unique in that background (caused by cosmic rays and radioactive materials in the vicinity) is only 2 counts/min, as contrasted with a normal background of 15-20 counts/min in conventional systems of this type. Expected to have wide use in biomedical, health physics, and industrial laboratories where radioactive samples must be analyzed in quantity.—*Nuclear-Chicago Corp.*, 359 *East Howard Ave., Des Plaines, Ill.*

CIRCLE 319 ON READER-SERVICE CARD

A Superior Detector for Infra-Red Spectroscopy

GOLAY PNEUMATIC DETECTOR*

Among the characteristics that render the Golay Detector superior to other types of detectors for use in infra-red spectroscopy are:

1. **An effective sensitive area 3/32" in diameter.**
2. **Sensitivity of 6 x 10^{-11} watts RMS-ENI when used with "chopped beam" method and with recording time constant of 1.6 second.**
3. **Uniform sensitivity from the ultra-violet through the visible and the entire infra-red, and up to the microwave region.**
4. **Improved, drift-free. A. C. operated amplifier with step gain controls and four response periods.**

Write for EPLAB Bulletin No. 10

*Fundamental and experimental aspects of this detector are discussed in the following publications: Rev. Sci. Inst. 18, 347 and 357 ('47); Ibid. 20, 816 ('49); Proc. IRE 40, 1161 ('52).

278-8

THE EPPLEY LABORATORY, INC.
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MODEL HA 150R
A 60 kV unit is also available.

NEW CARL ZEISS **High Voltage Supply Unit**

with built-in electronic stabilizer. 150 *kV D.C.*
Made in West Germany

This new unit embodies the most advanced features and offers important advantages in research and technical fields. It can be used for: High voltage supply for electron-optical examinations . . . Examinations of structure by means of electron diffraction . . . Deflecting voltage for particle accelerators . . . High voltage source for neutron generators . . . Electric testing of materials . . . Electrostatic spraying . . . Electronic sorting . . . High voltage supply during lectures, etc.

A safety device is incorporated to protect the operator against being subjected to dangerous high-voltage discharges. The unit is free of disturbing high-frequency radiation, and has only small interfering magnetic fields. Line voltage fluctuations of ±10% have practically no influence upon output. Mounted on casters —easily movable.

Write for literature.

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DE-LINE
THE ENGINEER'S

ANNUNCIATOR
GREATEST FLEXIBILITY IN THE FIELD

AVAILABLE IN MANY SEQUENCES

BACKLIGHTED
OR
BULL'S-EYE

SIDE BY SIDE OR STACKED, DE-LINE modular design retains original custom appearance as system grows.

SAME PLUG-IN operates from normally open OR normally closed trouble contacts.

AUXILIARY CONTACTS N.O.-N.C. standard with most plug-ins.

SEQUENCE OPTION after installation by means of independent slide switch at each point.

DE-LINE plug-ins are self-policing. Systems are rugged and dependable.

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COMPLETE MONITORING SYSTEMS FOR INDUSTRY

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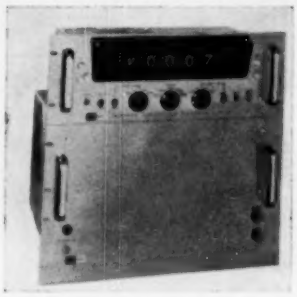
MILSPEC DIGITAL VOLTMETER



New Digital Voltmeter, Model 412, designed to conform with MIL-E-4158A, uses a box-within-a-box technique to provide protection against shock, humidity, and vibration, as well as excellent electrical isolation. Other features are two-channel capacity and output for a digital printer.—*KIN TEL Div. of Cohu Electronics, San Diego, Calif.*

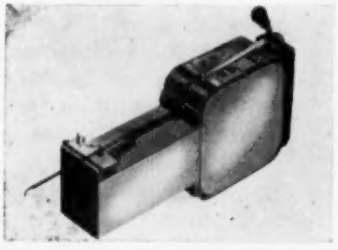
CIRCLE 320 ON READER-SERVICE CARD

HI-TEMP COLORS

New Heat-Rem H-170 in 18 high-heat-resisting Colors is reputed to permit color coding or complete finishing of metal components subjected to temperatures from 600° to as high as 1700°. Most colors contain a combination of "non-leafing" aluminum and a special metallic pigment. Unlike ordinary aluminum, non-leafing particles are said to remain equally distributed and in constant suspension with the pigment throughout the H-170 vehicle and provide uniform coverage in the applied coat.—*Speco, Inc., 7308 Associate Ave., Cleveland 9, Ohio.*

CIRCLE 321 ON READER-SERVICE CARD

PEN MOTOR



New 40-mm Pen Motor, Model OS-600, for ink writing on true rectangular coordinates is capable of recording signals from dc to 100 cps and over. An integral part of all Massa 40-mm recording systems, the pen motor itself can be used separately, providing a proper driving source. An interchangeable electric stylus is available for electric writing.—*Massa Div. of Cohu Electronics, Inc., 5 Fottler Rd., Hingham, Mass.*

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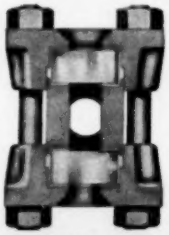
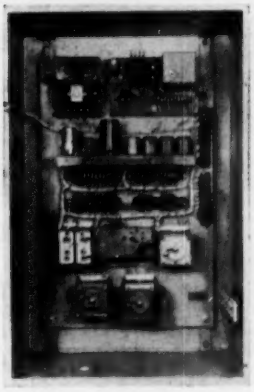
Strahman
HIGH PRESSURE GAUGES
USED IN REFINERIES AND CHEMICAL PLANTS THROUGHOUT THE WORLD

THRU VISION

REFLEX
Single or Multiple Sections

TUBULAR
Gauge Cocks
•
Large Chamber Reflex Gauges
•
Heated or Cooled Gauges
SEND FOR COMPLETE CATALOGUE
STRAHMAN VALVES, Inc.
NICOLET AVE., FLORHAM PARK, N. J.

CIRCLE 155 ON READER-SERVICE CARD

START-STOP SYSTEM



New design refinements in its automatic magnetically-controlled Start-Stop System for electric power switching operations include anticipatory functions. Controller automatically starts either a diesel or gasoline generator set, upon interruption of primary power; and when the auxiliary system reaches the proper voltage and frequency value, blocks out the primary source, and transfers the load to the auxiliary systems.—*Lumen, Inc., Joliet, Ill.*

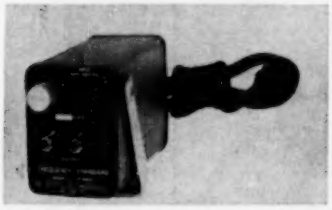
CIRCLE 323 ON READER-SERVICE CARD

REFRACTORY METAL T/C

New refractory metal Thermocouple combination for reliable temperature measurement up to 2800°C (5072°F) consisting of tungsten vs tungsten-26% rhenium is suitable for use in vacuum, hydrogen, or inert gases such as nitrogen, argon, and helium. It should not be used under oxidizing conditions or in the presence of hydrocarbon vapors as they will attack tungsten at temperatures above 1000°C.—*Engelhard Industries, Inc., 75 Austin St., Newark 2, N. J.*

CIRCLE 324 ON READER-SERVICE CARD

FREQUENCY STANDARD



New low-cost Frequency Standard, Model JF400 Tuning Fork Oscillator, consists of an electronically driven tuning fork and output filter. The unit employs a new piezoelectric tuning fork assembly in conjunction with a highly efficient driving circuit. Complete with power supply for operation from 115/60 cps line.—*Industrial Test Equipment Co., 55 East 11th St., New York 3, N. Y.*

CIRCLE 325 ON READER-SERVICE CARD

READ differential or gauge pressure *quickly... accurately... reliably*

Wallace & Tiernan Aneroid Dial Indicators give you fast response, high sensitivity, reliable accuracy.

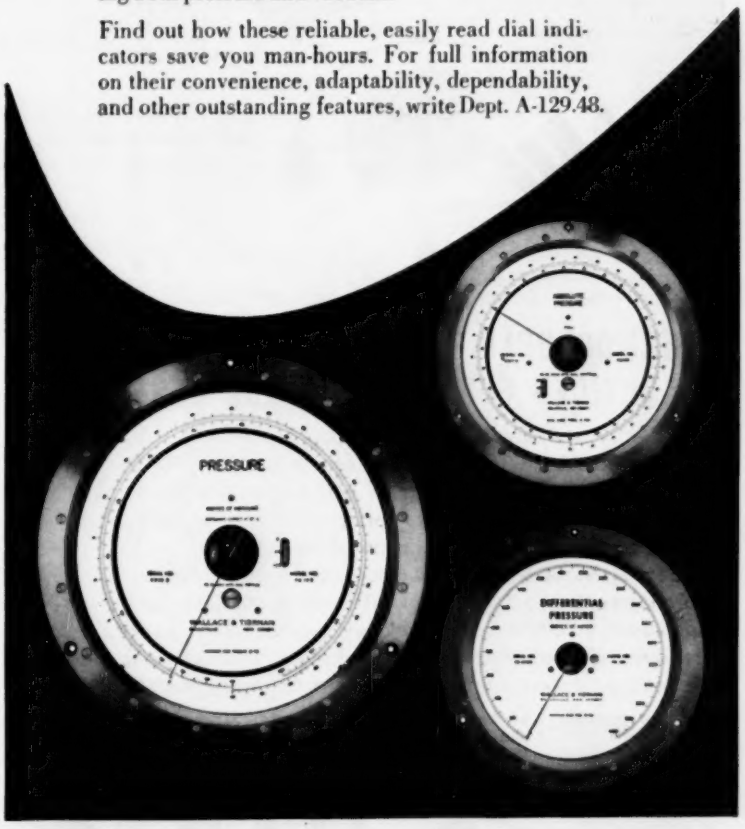
Whether you're in testing, manufacture, or research, there's a W&T Dial Indicator that's ideal over a wide range of differential or gauge pressures.

A W&T Aneroid Dial Indicator guarantees you:

- ★ Accuracy 0.1% to 0.33%
- ★ Sensitivity 0.01% to 0.2%
- ★ Range 0-10″ H_2O to 0-500 p.s.i.g.
- ★ Light weight, small size
- ★ Custom-calibrated dial
- ★ No corrections

W&T Aneroid Dial Indicators are also furnished as compound gauges with zero center for measuring both pressure and vacuum.

Find out how these reliable, easily read dial indicators save you man-hours. For full information on their convenience, adaptability, dependability, and other outstanding features, write Dept. A-129.48.



WALLACE & TIERNAN INCORPORATED

25 MAIN STREET, BELLEVILLE 9, NEW JERSEY

CIRCLE 156 ON READER-SERVICE CARD

inventive accomplishment in temperature sensing

from HARCO...

HARNESSES
complete line of standard parts and techniques to meet the exacting demands of modern thermocouple circuitry . . . standard or special applications. Bulletin 202.

CONNECTORS
accommodate greatest possible number of thermocouples in smallest space . . . yet have the mechanical strength and temperature resistance necessary to meet severe environmental conditions. Bulletin 185.

COMPLETE LINE OF METAL SHEATHED THERMOCOUPLES
especially for rapid, accurate, economical temperature sensing applications industry-wide. Accuracy of calibration well within recommended I.S.A. limits. Bulletin 161.

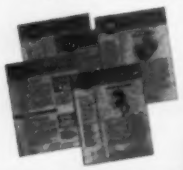
NEW CALIBRATION STAND
available in many models. Furnace design for acceptance of many different T/C configurations is available. Accuracy of readout within ±½°F. Bulletin 201.

NEW T/C REFERENCE JUNCTION COMPENSATOR
completely eliminates need for conventional ice bath as reference temperature source in thermocouple calibration. Several models, all with fifteen channels. Bulletin 201.

THERMOCOUPLE THERMOMETRY... PRECISION DEVICES FOR TEMPERATURE SENSING

All HARCO equipment . . . thermocouples, special potentiometers, pulse dividers, extension leads, pressure probes, and the devices shown above . . . is subjected to rigorous quality-control and inspection procedures to ensure performance accuracy and reliability, in application after countless application.

Because of today's rapid advances in both equipment and process development, the number of different temperature problems is increasing greatly . . . as is the close degree of accuracy and certainty required in their solution . . . and there is HARCO equipment to assist the solution of any such problem, however unique.



For further information on any HARCO product mentioned, write for specific literature, or ask for the name of the HARCO representative near you. If no standard HARCO device suits your special needs, we'll design a special one for you. Inquire.

HARCO LABORATORIES *Inc.*

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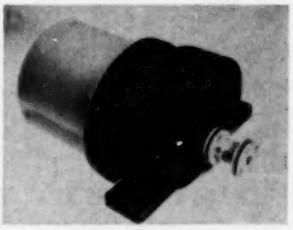
CIRCLE 157 ON READER-SERVICE CARD

REMOTE MIKE

New Carson-Dice Remote-Mike takes automatic micrometer measurements to 10 millionths of an inch from far away and displays digital readout on a counter on operator's console. Micrometer consists of micrometer head operating on the screw thread principle, a control console, and connecting cable. Head can be remotely zeroed in at any point within its measuring range.—*J. W. Dice Co., Englewood, N. J.*

CIRCLE 326 ON READER-SERVICE CARD

POSITION INDICATOR



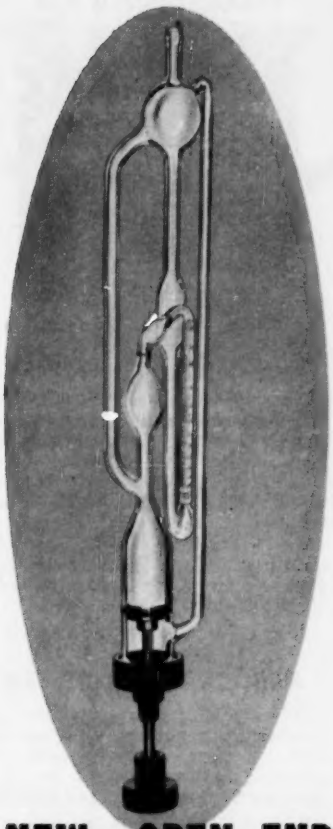
New high-speed Position Indicator system comprises a position sensor and a position indicator. Signals from the position sensor are transmitted electrically to a numerical indicator which displays readings in any required units. Positions are accurately read at speeds of 130 ft/min, accelerations up to 1 ft/sec². —*Sanders Associates, Inc., 95 Canal St., Nashua, N. H.*

CIRCLE 327 ON READER-SERVICE CARD

MINI PRESSURE SWITCH

New light-weight Pressure Switch weighs only ½ oz and measures 1-9/32" from the base to the top of the terminals. A simplified design involving only one moving part insures trouble-free operation and high sensitivity. Operating pressure range is from 0 to 500 psi, with a repeatable accuracy to within ±0.5%. An SPDT miniswitch is enclosed in the housing, with contacts rated for 6 amps at 125/250 v ac. An included ⅛" NPT fitting connects the switch to the pressure source. Flyer gives details. —*Pamar Electronics, a sub. of Hoke Inc., 1 Tenakill Park, Cresskill, N. J.*

CIRCLE 328 ON READER-SERVICE CARD



NEW...OPEN END McLEOD GAUGE

COMPRESSES GAS BETWEEN TWO MERCURY COLUMNS...

ELIMINATES CAPILLARY CONTAMINATION...

GIVES EASY, ACCURATE READING!

Two Scales 0-10mm. and 1-1000 micron Micrometric Adjustment of Mercury Meniscus!

Most simplified and accurate McLeod Gauge yet devised! No closed end capillary to become contaminated... no needlessly complicating comparison capillary... no more compounding of error in measuring—*one* direct reading manometer replaces former 2 tubes! Rubber "O" ring vacuum sealed piston operating in precision bore tube allows micrometric adjustment of mercury meniscus. You get most rapid, most accurate readings ever!

VG1100 VACUUM GAUGE, OPEN END McLEOD TYPE, 18" long, ready for use but without mercury. 69.50

Write for Bulletin VG.

See Your Laboratory Dealer

MANOSTAT *Corporation*

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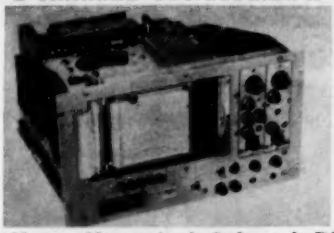
CIRCLE 158 ON READER-SERVICE CARD

2-CHANNEL OSCILLOGRAPH



New self-contained 2-channel Direct Writing Oscillograph, Model 297, can be either rack mounted in 10 ½" of panel space or housed in a portable case. Using plug-in interchangeable "850" style preamplifiers, which are available in many different types, it features low impedance, enclosed galvanometers; 4 pushbutton chart speeds; immediately visible traces by heated stylus on rectangular coordinate charts; and full 50-mm wide recording channels. Frequency response is to 125 cps, within 3 db at 10 mm peak-to-peak amplitude; gain stability is better than 1% max; non-linearity 0.2 mm.—*Sanborn Co., Industrial Div., 175 Wyman St., Waltham 54, Mass.*

CIRCLE 329 ON READER-SERVICE CARD

TRAVELING-WAVE TUBE P/S

New Power Supply Units, specifically designed to furnish all the voltages required for operation of traveling wave tubes, have output voltages continuously adjustable from zero to rated maximum. Typical outputs are 0 to 4000 vdc at 1 amp (beam); 0-300 vdc at 50 ma (bias); 0-220 vdc at 8 amps (magnet); and 0-15 vac at 15 amps (heater).—*Sorensen & Co., Richards Ave., South Norwalk, Conn.*

CIRCLE 330 ON READER-SERVICE CARD

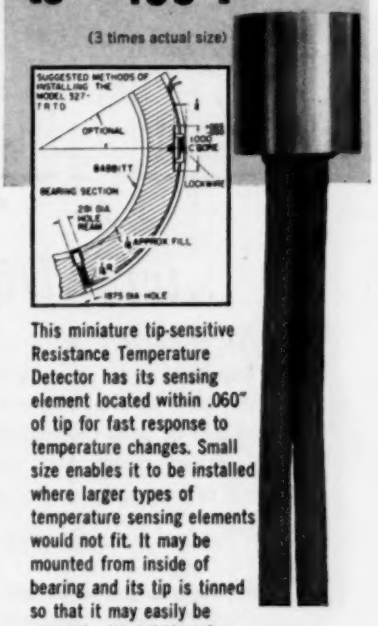
ANALOG COMPUTER

New CM-3 Analog Computer, featuring all-solid-state electronics, provides continuous "real-time" solutions for mathematical computations and "real-time" control of variables in the chemical, petro-chemical, refining, and process industries.—*Southwestern Industrial Electronics Co., a div. of Dresser Industries, Inc., 10201 Westheimer, Box 22187, Houston 27, Tex.*

CIRCLE 331 ON READER-SERVICE CARD

EDISON MINIATURE RTD 327-7 MEASURES PRECISE TEMPERATURES from −70° to +450°F

(3 times actual size)



This miniature tip-sensitive Resistance Temperature Detector has its sensing element located within .060" of tip for fast response to temperature changes. Small size enables it to be installed where larger types of temperature sensing elements would not fit. It may be mounted from inside of bearing and its tip is tinned so that it may easily be covered with babbitt after installation. Use with terminal 41820. For complete information, write for Reference Data Sheet 1045A9.

SPECIFICATIONS:

- Temperature Resistance Characteristic: No. 7
- Time Constant in Water: 4.0 sec.
- Maximum Current in Bearing: 0.015 amps
- Maximum Pressure: 2500 psi in babbitt installation

THOMAS A. EDISON INDUSTRIES
INSTRUMENT DIVISION
West Orange, New Jersey

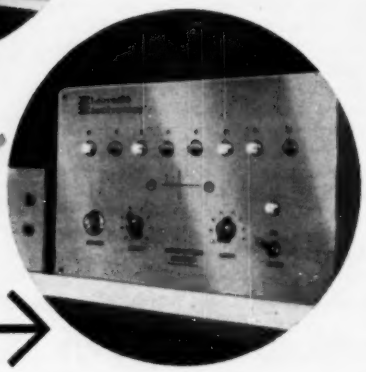
McGRAW EDISON

CIRCLE 159 ON READER-SERVICE CARD

How Do You Measure and Sort?

This way...

or this way...



...with Digital Display

Here are two ways of presenting accurate measurement information. One requires a scope and a skilled operator. The other—an Eldorado system—gives the result in easily read digital form. The Eldorado system can be used by unskilled personnel to give more accurate results at lower costs and, since it is a digital system, it can be adapted to automatic control production or test processes.

Two Typical Functions of Eldorado Systems:

1 **Analysis as to Size.** Eldorado has basic circuits which analyze pulse height. All that is required is a transducer capable of feeding pulses proportional to size of the physical phenomena to be measured and sorted.

2 **Analysis as to Time.** Other Eldorado systems accurately count and store the number of events occurring in any number of discrete and consecutive time intervals. Again, the only other component needed aside from the system is a transducer.

NOTE: Each Eldorado system is designed for a specific application. Eldorado will be happy to discuss yours in detail. Contact your Eldorado representative, or write us direct. You'll have a quick answer.

17 *Please address Dept. 54*

Eldorado Electronics

2821 TENTH STREET • BERKELEY 10, CALIFORNIA

CIRCLE 160 ON READER-SERVICE CARD

TRANSISTORIZED P/S

New transistorized, regulated d-c voltage Power Supply, features extremely low a-c ripple, kept below 1 mv rms by highly efficient filtering circuits. A 2% d'Arsonval meter has three ranges: 0-25v, 0-100ma, and 0-200ma. Zener-diode reference is used in the 3-transistor regulating circuit.—*Electro Products Labs., Inc., 4500 N. Ravenswood Ave., Chicago 40, Ill.*

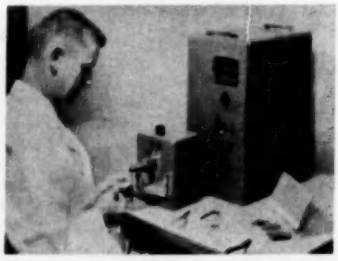
CIRCLE 332 ON READER-SERVICE CARD

MONITOR/ALARM SYSTEM

New Monitor/Alarm System unit verifies the condition of 30 stations with an accuracy of one part in a thousand in less than 0.3 sec. It is intended for process control, hospital patient monitoring, reactor and power generation, and human endurance applications. Signals from transducers representing temperatures, pressures, liquid flows, displacements are fed to the alarm system. The allowable or permissible values for each station are punched in advance into an IBM card.—*Franklin Electronics Inc., 5901 Noble Ave., Van Nuys, Calif.*

CIRCLE 333 ON READER-SERVICE CARD

WELDING HEAD



New Model 1037 is a new bench-mounted Welding Head featuring twin ball-bearing races for precise control over the placement of the weld, eliminating electrode wiping action, as pre-set electrode pressure variable from 2 to 50 lb is applied to fine wire leads and other critical applications.—*Weldmatic Div. of Unitek Corp., 950 Royal Oaks Dr., Monrovia, Calif.*

CIRCLE 334 ON READER-SERVICE CARD

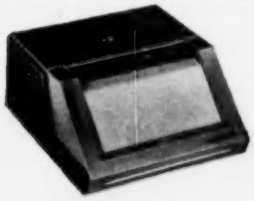
Unmatched versatility with

PHOTRON

OSCILLOGRAPHS and AMPLIFIERS

OSCILLOGRAPHS

Rectilinear recording with ink or heated stylus. **Curvilinear** recording with ink or electric stylus. AC or DC* chart drive. Frequency response from DC to 150 cps.

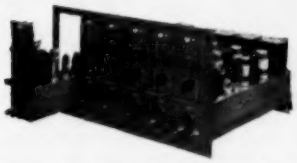


Up to 8 channels.
Portable or rack mounted.

●

NEW Operational Amplifier

Chopper stabilized with feedback attenuation. Single units or modules of 6.



Fixed gain settings from unity to 1000.

●

General Purpose Amplifiers

DC, Chopper Stabilized, and Carrier amplifiers for use with any direct-writing galvanometer or for general laboratory use. Gains from 25 to 10,000. Frequency response from DC to 50kc. *Request Bulletin 210.*

●

NOW AVAILABLE:

Transistorized galvanometers with voltage gains up to 10, and current gains up to 1000. The use of silicon transistors assures good temperature stability. *Request Bulletin 220.*

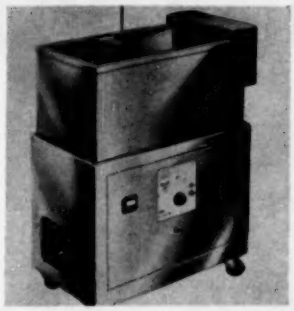
*for airborne recording

PHOTRON INSTRUMENT COMPANY

6516 Detroit Ave. • Cleveland 2, Ohio

CIRCLE 161 ON READER-SERVICE CARD

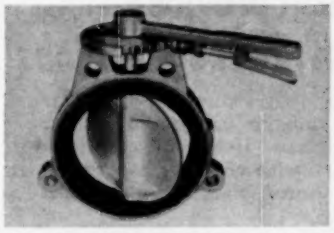
REFRIGERATED BATH



New Magni-Whirl Refrigerated Bath, equipped with saturable-power-reactor control is ideal for calibrating processes as there is no cycling of controls or transient voltages due to arcing controls.—*Blue M Electric Co., 138th and Chatham St., Blue Island, Ill.*

CIRCLE 335 ON READER-SERVICE CARD

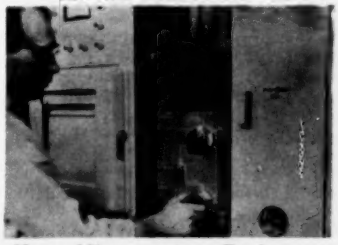
BUTTERFLY VALVE



New Resilient-Seated Butterfly Valve is much smaller in overall dimensions and weighs but a small fraction of that of a gate valve. The streamlined shape of the disc enhances straight-through flow of the fluid without changes in direction. The disc seats against the resilient seat liner of molded, abrasion-resistant rubber or synt'etic elastomers.—*W. S. Rockwell Co., 200 Eliot St., Fairfield, Conn.*

CIRCLE 336 ON READER-SERVICE CARD

MICRO-REACTOR UNIT

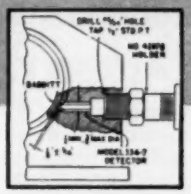


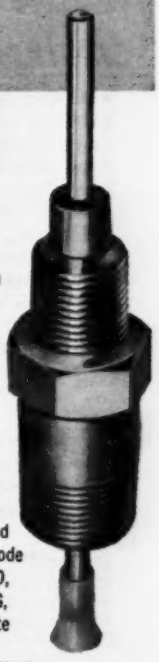
New Micro-reactor Device, permitting use of the microcatalytic-chromatographic technique with its Model 154D vapor fractometer, which is a modification of the standard gas sampling valve, makes it possible to rapidly survey the activities of a series of catalysts using a flow-type reactor.—*Perkin-Elmer Corp., Norwalk, Conn.*

CIRCLE 337 ON READER-SERVICE CARD

EDISON

RTD 334-7 MEASURES BEARING TEMPERATURES IN EXPLOSIVE ATMOSPHERES from −70° to +500°F





This tip-sensitive general purpose Resistance Temperature Detector is designed to measure such metal temperatures as machinery bearings. Responds to temperature changes at its tip only and is unaffected by temperatures around tubing. Used with holder 42078, this hermetically sealed RTD is suitable for application in hazardous areas defined by... National Electrical Code as Class I, Groups C and D, Class II, Groups E, F and G, and Class III. For complete information, write for Reference Data Sheet 1045A-11.

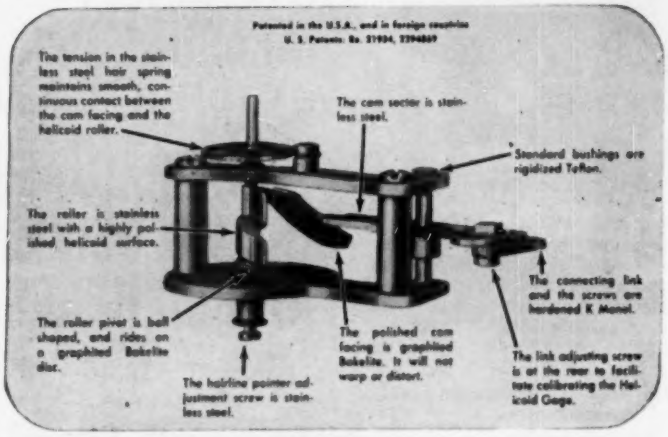
SPECIFICATIONS:

Temperature Resistance Characteristic: No. 7
Time Constant in Agitated Water: 2 sec.
Maximum Current in Air: .015 amps; in Water: .025 amps.
Maximum Pressure: 200 psi

THOMAS A. EDISON INDUSTRIES
INSTRUMENT DIVISION
West Orange, New Jersey

McGRAW EDISON

CIRCLE 162 ON READER-SERVICE CARD


Patented in the U.S.A., and in foreign countries
U. S. Patents: Re. 21934, 2294869
The tension in the stainless steel hair spring maintains smooth, continuous contact between the cam facing and the helicoid roller.
The cam sector is stainless steel.
Standard bushings are rigidized Teflon.
The roller is stainless steel with a highly polished helicoid surface.
The connecting link and the screws are hardened K Monel.
The roller pivot is ball shaped, and rides on a graphited Bakelite disc.
The polished cam facing is graphited Bakelite. It will not warp or distort.
The link adjusting screw is at the rear to facilitate calibrating the Helicoid Gage.
The hairline pointer adjustment screw is stainless steel.

Exclusive Helicoid movement provides...
Sustained Accuracy...on the toughest jobs

• Helicoid Gages have no gears, no teeth, reducing wear to an absolute minimum. No danger of fouling, either—rolling action of cam facing keeps contact surface clean. Helicoid Gages have been tested through 75,000,000 cycles, with virtually no wear or loss of accuracy, while conventional geared gages became useless after 500,000 cycles.

Helicoid Gages give *sustained* accuracy even when subjected to violent pressure pulsations or mechanical vibrations. Pointer can be set externally, without removing glass, and cannot be jarred out of position. Dial faces are easy to read, won't corrode or chip. A full range of Helicoid Gages is available for any application. Next time, specify Helicoid—the gage that *stays* accurate.

Bourdon Tubes won't Stretch, Leak, or Crack

Helicoid Bourdon tubes are made from seamless tubing, and are designed for maximum torque and minimum stress. At the factory, each tube is individually tested, overpressured, and stress relieved. Four materials—alloy steel, K Monel, stainless steel, and phosphor bronze—are available to meet applications ranging from tap water to almost any acid.

NEW! Solid-Front Safety Case Gives Added Protection

The new Helicoid solid-front case diverts the force of a burst in a backward direction, away from the operator. The force escapes by deforming, though not detaching, the back cover plate. Helicoid Gages are also available in phenol, acaloy flanged, acaloy flangeless, polished flangeless, round flush, polished flush ring, and square flush cases.

WRITE for details **Ask for Catalog DH-65**

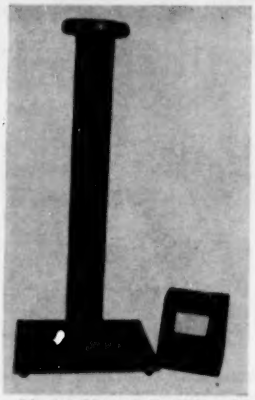
HELICOID GAGES

Helicoid Gage Division • American Chain & Cable Company, Inc.

929-B Connecticut Ave., Bridgeport 2, Conn.

CIRCLE 163 ON READER-SERVICE CARD

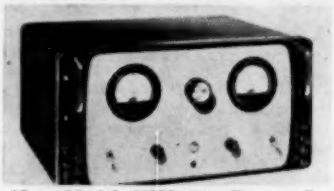
200,000 VDC VOLTMETER



New Model M200DC, Kilovoltmeter, a 200,000-volt D-C Voltmeter is composed of a high-voltage multiplier resistor in a tall bakelite tube, and an indicating instrument in a small metal cabinet at ground potential. It has an input resistance of 2,000 megohms, a 4½" square indicating instrument, and will take an overload of 150%. A large corona shield minimizes corona and a neon gap overvoltage circuit protects the indicating instrument.—*Peschel Electronics, Inc., Towners, Patterson, N. Y.*

CIRCLE 338 ON READER-SERVICE CARD

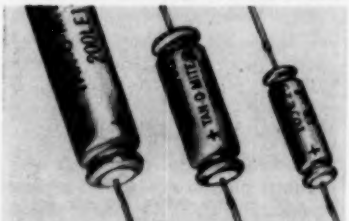
HI CURRENT POWER SUPPLY



New Model UHR-211 Power Supply features output voltage of 130 to 500 vdc; current, 0 to 1,000 mamp at any voltage setting and at any line voltage over the operating range. Ripple is less than 0.2 mv rms.—*Krohn-Hite Corp., 580 Mass. Ave., Cambridge 39, Mass.*

CIRCLE 339 ON READER-SERVICE CARD

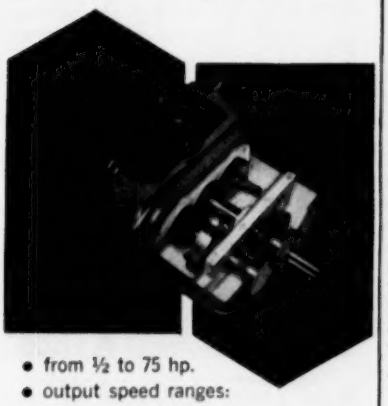
TANTALUM FOIL CAPACITORS



New etched-foil tantalum Electrolytic Capacitors made in 3 sizes, equivalent to case sizes C1, C2 and C3 of MIL-C-3965B, collectively provide a range of 0.5 to 200 mf and working voltages to 150 vdc.—*Ohmite Mfg. Co., 3684 Howard St., Skokie, Ill.*

CIRCLE 340 ON READER-SERVICE CARD

Specify
SPECON for
VARIABLE SPEED DRIVES
electrical and mechanical



- from ½ to 75 hp.
- output speed ranges: 0-100 to 0-7000 rpm
- smoothly adjustable through zero speed
- draw accuracies of .01%
- full torque at zero speed

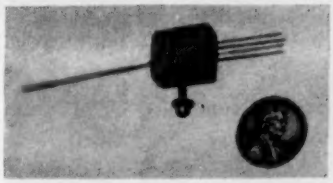
These are just some of the outstanding characteristics of Specon variable speed drives. Rugged, reliable and requiring minimum maintenance, they permit infinitely fine adjustment of output speed with accuracies approaching fixed gearing. Specon drives also feature shockless starts and acceleration, full reversing, and provide output speeds up to 7000 rpm while maintaining zero speed features.

Send for FREE data booklet on Specon variable speed drives.

STRATOS
A DIVISION OF FAIRCHILD ENGINE & AIRPLANE CORPORATION
INDUSTRIAL PRODUCTS BRANCH
#42, Route 109, West Babylon, N. Y.

CIRCLE 164 ON READER-SERVICE CARD

MINI DC/AC CHOPPER



New Type 40 microminiature DC/AC Chopper is housed in a 5/16" x ½" x ⅝" metal casement which incorporates a rugged taut-band armature suspension and an armature action. Improved armature suspension, greater drive and increased contact area are its main features. Available in the following ranges: 20 to 150 cps, 400 to 600 cps, and 1000 to 1500 cps with coil excitation voltages from 3 to 28 v square or sine wave.—*Raweo Instruments, Inc., 3527 West Rosedale, Fort Worth 7, Tex.*

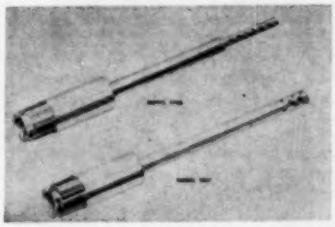
CIRCLE 341 ON READER-SERVICE CARD

ELECTRICAL VACUUM GAGE

New Vacuum Gage, Model SP-3, covering the range of 10-200 mm Hg abs is believed to be the first electrical gage in this pressure range. A noble-metal thermopile is the sensing element. Freedom from outgassing, system contamination, corrosion, and rust are assured by its thermopile and by a nickel-plated tube. Available in cabinet-, panel-, control-, and recorder-type instruments. Multiposition models for monitoring up to 5 positions are also available.—*Hastings-Raydist, Inc., Hampton, Virginia.*

CIRCLE 342 ON READER-SERVICE CARD

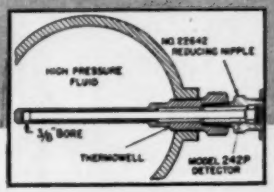
PRECISION PROBES



New precision platinum Temperature Sensors, available from stock, include enclosed and open models, 9 stem lengths and 6 different fittings. Model 179A uses a precise platinum resistance of 500 ohms at 32°F. Sensing element of Model 152T is rated 200 ohms at 32°F. Temperature range if from —435° to 500°F; lengths are from 1¾" to 2¾", in ⅛" increments; stability within 0.2° F at 32°F; pressure tested to 6000 psi; time constant of 0.5 sec for Model 179A, 0.2 seconds for Model 152T.—*Rosemount Engrg. Co., 4900 West 78th St., Minneapolis 24, Minn.*

CIRCLE 343 ON READER-SERVICE CARD

EDISON
RTD 242P MEASURES FLUID AND GAS TEMPERATURES from —100° to +1500°F



This stem-sensitive Resistance Temperature Detector can be operated in live steam and other high temperature atmospheres up to 1500°F. Widely used in the chemical and petroleum industries, the stainless steel 242P RTD provides readings to 0.01°F. For complete information, write for Reference Data Sheet 1045A-5.

SPECIFICATIONS:

Temperature Resistance Characteristic: No. 8
Time Constant in Agitated Water: 10 sec. approx.
Maximum Current in Air: 0.010 amps; in Water: 0.020 amps
Maximum Hydrostatic Pressure: 300 psi at 1380°F.

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INSTRUMENT DIVISION
West Orange, New Jersey
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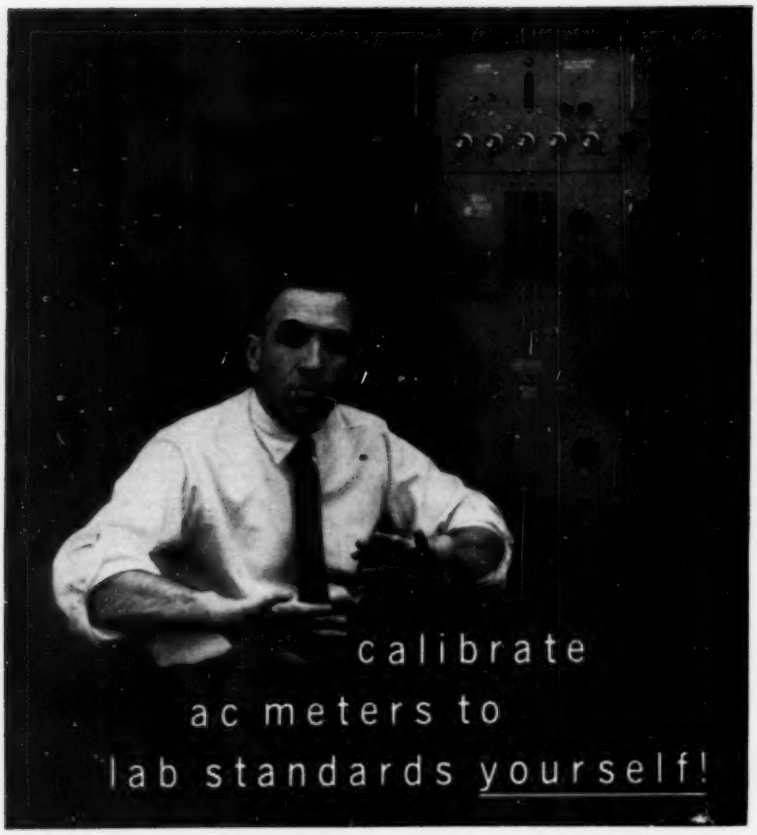
CIRCLE 165 ON READER-SERVICE CARD



with this stable,

low-distortion ac power source

New from Krohn-Hite: this variable-frequency, 50 watt ac power source, with less than 0.01% amplitude stability and 0.1% harmonic distortion! The LDS-1500 offers a continuously-variable wide range of voltage and current — up to 1500 volts, and up to 12 amps, at *any* frequency from 20 cps to 20 kc.

Here is the long-desired combination of short-term stability and low distortion for calibration, by the comparison method, of all conventional indicating ac voltmeters and ammeters, and digital meters normally used for laboratory measurements.

Now you can calibrate your own meters at precisely the frequencies you require. Because of the push-buttons and vernier controls, frequency settings are positive, convenient, and resettable to better than 0.01%.

As a general-purpose variable frequency source of distortion-free, highly stable power, the LDS-1500 has many other applications. Quality-control testing for distortion or performance of components requiring a variety of power supply frequencies is simplified. The 50 watt power output is ample to supply test benches.

Send for full information on this unusual ac power source!

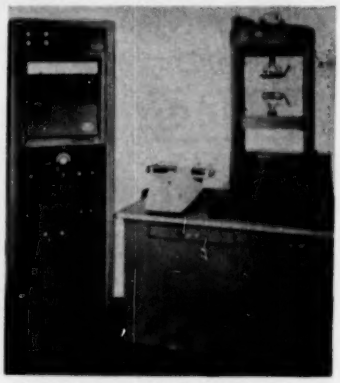
KROHN-HITE CORPORATION

580 Massachusetts Avenue • Cambridge 39, Mass.

Pioneering in Quality Electronic Instruments

CIRCLE 166 ON READER-SERVICE CARD

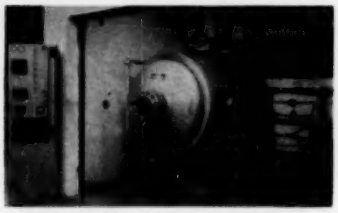
DIGITAL READOUT SYSTEMS



New Dynamic Digital Systems, consisting of a standard Instron Universal Testing Instrument equipped with encoders, memory storage units, and associated assemblies, converts through binary decimal code information normally presented in graphic form directly into automatic printing digital form.—*Instron Engineering Corp., 2500 Washington St., Canton, Mass.*

CIRCLE 344 ON READER-SERVICE CARD

EXPLOSION TEST CHAMBER



New Explosion Test Chamber, Model X3050, is designed for temperature operation to +200°F and altitudes to 100,000 ft. The explosive atmosphere is attained with propane gas or high octane gasoline. Conforms to MIL-E-5272-C. Complete with temperature, altitude, and fuel-mixture controls, relief valves which automatically compensate for altitude, and sampling chamber to check and prove the explosiveness of the fuel mixture prior to the operational test. —*Itemco Inc., 18 Beechwood Ave., Port Washington, N. Y.*

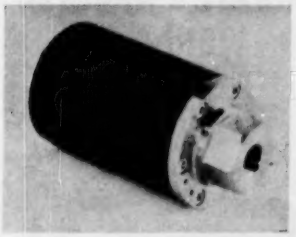
CIRCLE 345 ON READER-SERVICE CARD

CARTESIAN MANOMETER

New Cartesian Manometer, permits direct and continuous reading of 0-to-10 mm pressure measurements on a convenient, accurate 100-mm-long scale. Magnification by a factor of 10 makes exact readings far more readily obtainable than before, with a convenience no McLeod gage can match, and with an accuracy far beyond that of ordinary coarse manometers, rated at 1% of full scale.—*Emil Greiner Co., 20-26 North Moore St., New York 13, N. Y.*

CIRCLE 346 ON READER-SERVICE CARD

PRESSURE TRANSDUCER



New d-c Pressure Transducer, Model CP51, operable from the 115v-ac line, combines in a single housing a variable reluctance transducer and a carrier-demodulator for dynamic as well as steady-state pressure measurement. Unit can be furnished with output of 0—5 vdc for voltage controlled systems or 0—1 ma for galvanometer recording. It accepts corrosive liquids and gases both sides, and is available in ranges 0.5 to 1,000 psig, differential, gage, or absolute. Shock or static acceleration of 100 G's any axis, and vibration, of 35 G's, 50—2,000 cps will not affect calibration.—*Pace Engineering Co., 13035 Saticoy St., North Hollywood, Calif.*

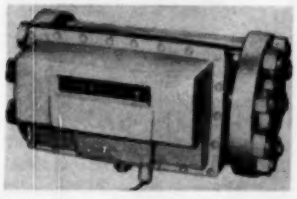
CIRCLE 347 ON READER-SERVICE CARD

RADIATION THERMOMETER

New Thermodot Radiation Thermometer, Model TD-3, remotely measures temperatures of moving and inaccessible surfaces without contact. Temperature range is from 180°F to 4000°F. Bulletin R-102 gives details. —*Radiation Electronics Co., Comptometer Corp., 5600 Jarvis Ave., Chicago 48, Ill.*

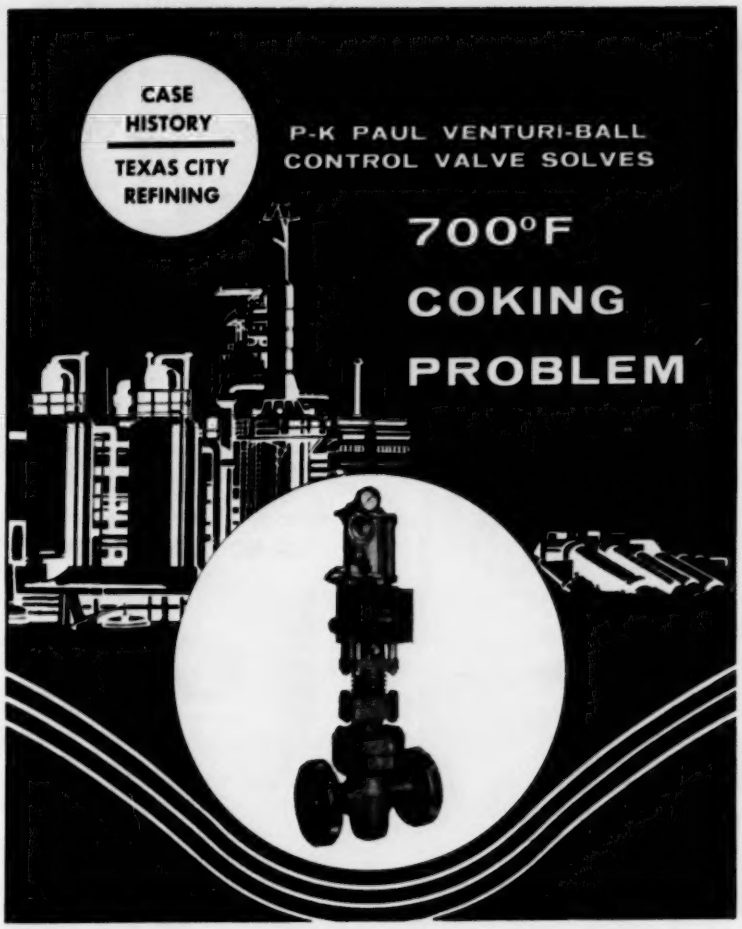
CIRCLE 348 ON READER-SERVICE CARD

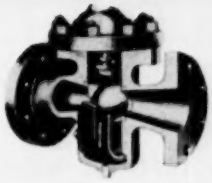
MASS FLOWMETER



New Mass Flowmeter for natural gas, jointly developed by BS&B and GE, makes possible the measurement of gas directly in pounds, eliminating calculations for conversion of volume to weight. The flowmeter, which can be designed into remote controlled systems, utilizes a sensing device that consists of a constant-speed impeller and a stationary turbine, arranged for axial flow. The impeller gives a twist to the fluid stream and the fixed turbine straightens the stream. The torque exerted on the turbine in proportional to the mass rate of flow.—*Black, Sivalls, & Bryson, Inc., 7500 East Twelfth St., Kansas City 26, Mo.*

CIRCLE 349 ON READER-SERVICE CARD





- Higher Flow Capacity
- Wide Rangeability
- Positive Shut-Off
- Straight Through, Non-Turbulent Flow
- Low Operating Thrust
- Self-purging
- Highly Resistant to Erosion and Abrasion

"Coking has been a problem on valves for 15 years at this plant. In March, 1958 a P-K Paul Venturi-Ball Valve was installed in the feed line to No. 1 Vacuum Tower. This is heavy oil from Tar Separator Tower and is one of the roughest services in the plant. Oil is flowing at 700°F and contains coke and coke fines. **No previous valve had ever performed satisfactorily prior to this time.**

" . . . The valve has given continuous service since being installed. Recommended spare parts are unnecessary — nothing has worn out on these valves."

This is one more example of General Kinetics' ability to solve a particularly tough problem. For operations requiring reliable control valves, General Kinetics offers a complete line of P-K Paul Venturi-Ball Control Valves.

Write today for the 16 page Technical Bulletin GV 101

General Kinetics Corporation

197 South Van Brunt Street · Englewood, New Jersey

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it's

TIME

to investigate

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The Parabam Digital Clock provides accurate time-of-day for...

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- ★ PROCESS CONTROL
- ★ DATA PROCESSING
- ★ COMPUTING SYSTEMS
- ★ TEST DATA RECORDING

up to 86,400 contact combinations.

- Time-of-day readings in increments of one minute, tenth-minute or one second.
- Multiple or single outputs in decimal code and various codes of binary coded decimal.
- Single plane, in-line lamp bank display. 1" high numerals. (Display also available for remote mounting.)
- 24 hour or 12 hour AM-PM configurations.

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for Technical Bulletin No. 460-5 on the Parabam Digital Clock.

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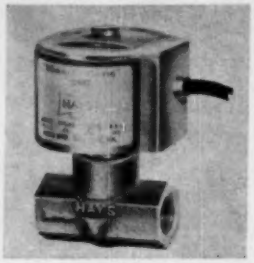
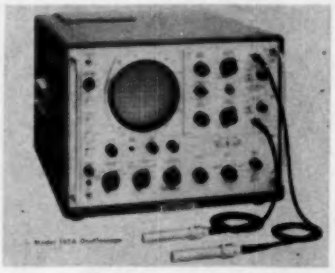
MIDGET SOLENOID VALVE



New Midg-O-Matic Solenoid Valve for automatic control of small flows of water or air is available in a wide range of voltages and solenoid types in angle or straight pattern. The waterproof coil, known as Kast-Coil, is guaranteed forever.—*Automatic Controls Div., Hays Mfg. Co., 805 West 12th St., Erie, Pa.*

CIRCLE 350 ON READER-SERVICE CARD

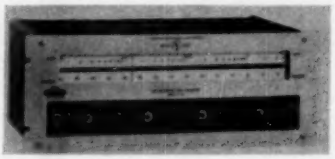
500-MC OSCILLOSCOPE



New 500-MC Oscilloscope, Model 185A, which provides viewing of repetitive millimicrosecond pulses has a rise time of less than 0.7 mμs, a full 10-cm vertical display, and high vertical amplifier sensitivity which permit pulse analysis in greater detail than previously possible.—*Hewlett-Packard Co., 275 Page Mill Rd., Palo Alto, Calif.*

CIRCLE 351 ON READER-SERVICE CARD

VACUUM TUBE VOLTMETER

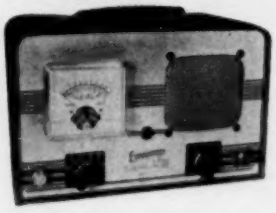


New Model HLV-150 Log VTVM features accuracy constant (2%) over full three decade scale, adjustable (plus or minus) O-DB reference over 70-db range, expanded 14"-scale with knife-edge pointer, and mirror which almost eliminates reading error, dc and 1 cps to UHF in one instrument, d-c floated output signal proportional to decibels for x-y, strip chart recording, or analog computation, over three decades without switching, and 5 Mohm input impedance (minimum) ac or dc.—*Houston Instrument Corp., Box 22234, Houston 27, Texas.*

CIRCLE 352 ON READER-SERVICE CARD

LOCATE • ANALYZE VIBRATION

ELECTRO PROBE



Electro Probe makes possible measurement and location of noise and vibration in mechanical systems; useful for design and quality control procedure. Invaluable in preventative maintenance.

New improved model uses voltage control tube stabilizing power supply voltage. Pickup is provided with holding magnet and rod. Let us help you with your noise and vibration problems.

Write for illustrated bulletin describing the Electro Probe.

ERWOOD, Inc.
1770 W. Berteau, Chicago 13, Ill.

CIRCLE 169 ON READER-SERVICE CARD

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IN-LINE DIGITAL DISPLAYS

A Model and Size for Your Every Requirement

Series 80000

Series 10000

Series 120000

OUTSTANDING FEATURES

- All digits displayed on front viewing screen
- All digits uniform in size and intensity
- High-contrast viewing screen
- Digit style of your choice
- Colored digits of your choice
- Individual units may be group assembled for panel mounting

WRITE TODAY FOR COMPLETE SPECIFICATIONS
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1 1/16" wide
2 3/8" high
5 1/8" long
$18.00 each

Series 80000
3 1/4" wide
5 1/4" high
11 1/16" long
$33.00 each

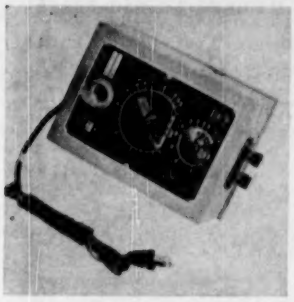
Series 120000
1" wide
1 1/16" high
3 7/8" long
$35.00 each

Quantity Prices On Request

INDUSTRIAL ELECTRONIC ENGINEERS, Inc.
5528 Vineland Avenue,
North Hollywood, Calif.

CIRCLE 170 ON READER-SERVICE CARD

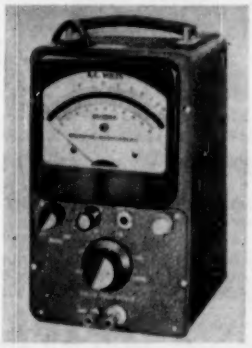
RESISTIVITY BRIDGE



New Solu-Bridge, Model RD-336, for checking the resistivity of hot, ultra-pure water in applications such as the components manufacturing field, where washing of transistors and semiconductor materials is essential, covers range of 1-18 megohm-cm specific resistance and has a manual temperature compensator calibrated at 70-100°C incorporating the characteristics of ultra-pure water.—*Industrial Instruments, Inc., 89 Commerce Rd., Cedar Grove, N. J*

CIRCLE 353 ON READER-SERVICE CARD

ELECTRONIC VOLTMETER



New Model 300-G precision Electronic Voltmeter features 1% accuracy over the entire meter scale from 1 mv to 250 v and over the band of 20 cps to 20 kc. It maintains an accuracy of better than 2% to 1,000 v and for the wider band of 10 cps to 250 kc. Voltage coverage is from 1 mv to 1,000 v in six decade ranges. Basic meter error is less than ±0.5% at all points on the scale.—*Ballantine Labs., Boonton, N. J.*

CIRCLE 354 ON READER-SERVICE CARD

DUAL BELLOWS ASSEMBLY

New Dual Bellows Assembly, capable of compensating for volumetric changes in full fluid throughout operating conditions, solves problem of providing a leak-tight chamber for a volume compensator in an oil-filled accelerometer. Unit which is nonmagnetic fits an envelope ¾" wide x 1⅝" long x 0.173" deep.—*Metal Bellows Corp., 27 Mica Lane, Wellesley, Mass.*

CIRCLE 355 ON READER-SERVICE CARD

HEISE GAUGES

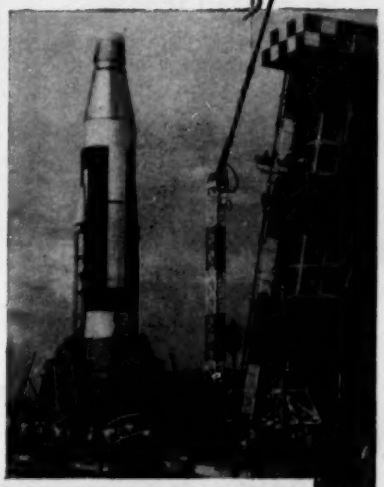
Critical Test Procedure

Analysis of ICBM components, such as the airborne transducer being tested here in the Standards Laboratory of Convair Astronautics, requires a superior "Test" instrument.

The Heise precision pressure gauge used for this work surpasses the highest rating for test gauges covered by the American Standards Association.

All Heise gauges are accurate to 0.1 of 1% of full scale reading.

ASA Grade AA test gauges are accurate to 0.5 of 1% of full scale reading.



The above photographs of the Atlas ICBM and the test stand featuring Heise Gauges were supplied by Convair (Astronautics) Division, General Dynamics Corporation, manufacturer of the Atlas.

The Atlas is designed to deliver a thermonuclear war head 6,325 statute miles.

PRESSURE RANGES	DIAL SIZES	PRICES	DELIVERY
15 to 100,000 P.S.I.	8½", 12", 16"	from $183.50	within 30 days

HEISE BOURDON TUBE COMPANY, INC.

BROOK ROAD, NEWTOWN, CONNECTICUT, U.S.A.

CIRCLE 171 ON READER-SERVICE CARD

VARIAN
Potentiometer
RECORDERS

Preferred for real differences,

for example . . .

7. ADJUSTMENTS MAKE THEM

VERSATILE

Zero is adjustable—left, right, center, or any uneven division of the chart to fit each particular use. Also, ranges from 0-9 millivolts to 0-100 volts. Such options as temperature recording are provided by interchangeable chassis and matching charts and scales.

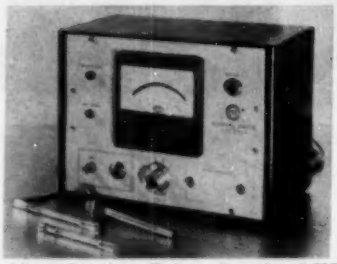
1% accuracy; 1 or 2½ seconds full-scale balancing time; portable, bench top or panel-mounted versions; single channel units weigh 15 pounds, dual channel 35 pounds; prices from $365; wide range of speeds and other options described in Varian literature. Write the Instrument Division.

VARIAN associates

PALO ALTO 27, CALIFORNIA

CIRCLE 172 ON READER-SERVICE CARD

SENSING TUBES



New Sensing Tubes for the LKB Produkter (Stockholm, Sweden) vacuum gage bolster the number of potential applications for the Autovac gage. One of the sensing tubes, made of Pyrex glass, was developed for direct sealing to glass systems. The tube, of stainless steel, has a 9.6-mm OD tubulation for installation in a metal system by means of a compression connector.—*Consolidated Vacuum Corp., 1775 Mt. Read Blvd., Rochester 3, N. Y.*

CIRMLE 356 ON READER-SERVICE CARD

ENVIRONMENTAL TEST ROOMS

New line of walk-in environmental rooms with two temperature ranges, ambient to 140°F, and 0° to 140°F, features accuracy within ±1°F. Dimensions are 6 ft x 6 ft x 8 ft, 6 ft x 10 ft, and 6 ft x 12 ft. Inside working height is 7 ft. Constructed of heavy-gage aluminum inside with corrugated aluminum floor plates in panel form, they are shipped knocked down.—*Labline, Inc., 3070-82 West Grand Ave., Chicago 22, Ill.*

CIRCLE 357 ON READER-SERVICE CARD

SOUND LEVEL METER

New portable, completely transistorized, battery-operated Sound Level Meter, Type 1400E, (made by Dawe Instruments, Ltd., London) features exceptional accuracy, stability, and sensitivity, and gives direct readings of sound pressure levels over the entire audio range from 24 db to 140db. Meter, which conforms to ASA and proposed IEC specifications, has a Rochelle-salt-crystal diaphragm-type microphone which folds into a recess in the end of the case.—*Korfund Co., Inc., 48-15, 32nd Place, Long Island City 1, N. Y.*

CIRCLE 358 ON READER-SERVICE CARD

MACHINE-DIVIDED SCALES

Made with latest
SIP Swiss Automatic Dividing Machines

LINEAR
Accuracy to ±5 microns (0.0002")

CIRCULAR
Accuracy to ±5 seconds

Any scale pattern—Any line width—Any material

FINE MACHINE ENGRAVING
Scales, Dials, Drums, Rods, Panels

ACCURATELY ETCHED RETICLES
Made in any specified pattern and dimensions

PRECISION MACHINE-RULED MASTERS
For printed circuits, i.e., commutators, switches, and general circuitry

L. C. RENICK CO.
308 So. Salsipuedes St., Santa Barbara, Calif.
formerly Cicero, Illinois

CIRCLE 173 ON READER-SERVICE CARD

TACHOMETERS

TYPE "UO"
UNIVERSAL CENTRIFUGAL TYPE
With Overspeed Protection
5 Ranges in each instrument
Cat. No. 308 30-12,000 RPM
Cat. No. 314 45-18,000 RPM
Cat. No. 322 60-24,000 RPM
Cat. No. 348 120-48,000 RPM
Bulletin 751

STATIONARY TYPE
MODEL "J"
Sizes, 3", 4", 5½", 8", 10", and 20" dial diameter, flexible shaft drives.
Many standard ranges reading RPM, FPM, YPM, etc.
Bulletins 795, 796, 797

VIBRATING REED TACHOMETERS
Portable and Stationary Types. Measure speed by touch. Many different ranges from 600-150,000 RPM.
Bulletin 770

High Intensity
STROBOSCOPE
Model 510-AL
Range 60 — 15,000 RPM
Industry's Seeing Eye
Bulletin 780
Booth #2011 ISA N.Y. Coliseum

HERMAN H. STICHT CO., INC.
27 PARK PLACE, NEW YORK 7, N. Y.

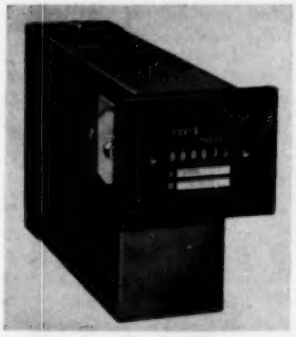
CIRCLE 174 ON READER-SERVICE CARD

WASTE WATER ANALYZER

New Analyzer for continuously determining and recording dissolved organic matter in chemical plant waste water has full-scale sensitivity of 200 ppm by weight of organic carbon which may be extended to about 1000 ppm. Concentration changes of approximately 1 ppm or organic carbon can be detected. Provisions are made for automatic standardization and analysis of batch samples.—*Lockwood & McLorie, Inc., Box* 113, *Hatboro, Penna.*

CIRCLE 359 ON READER-SERVICE CARD

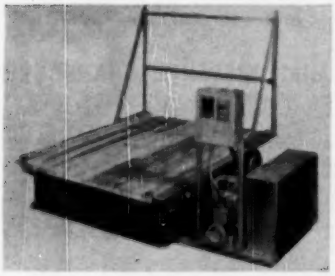
ELECTRIC INTEGRATOR



New Model R 790 Electric Integrator can be used for integrating any quantity that can be linearly represented by a d-c voltage or current signal in the 0-25 v range. This could include positive-displacement fluid motors driving tachometers, lineal measurement of webs and strips, etc. Integration is continuous and accurate to within ½ of 1% with flow turndowns of as much as 10 to 1.—*GPE Controls, Inc.,* 240 *E. Ontario St., Chicago* 11, *Ill.*

CIRCLE 360 ON READER-SERVICE CARD

VIBRATION TESTER



New compact Vibration Tester, Style 250-V, has a ¾-hp motor with a variable speed drive, controlled by snychronous interval timer which shuts off machine at proper time. Table size is 30" x 36", capacity is 250 lb, speed range is 100-300 rpm, floor area is 3½' x 4'.—*Gaynes Engineering Co.,* 1648 *W. Fulton St., Chicago* 12, *Ill.*

CIRCLE 361 ON READER-SERVICE CARD

2000°F 3000°F 4000°F

Con-O-Pak thermocouples are accurate to 4000° F

It is now possible to measure temperatures accurately in vacuums or inert atmospheres to 4000°F and above with a single homogeneous assembly. Due to their homogeneous structure Con-O-Pak thermocouples can be formed around an exceedingly small diameter without loss of insulation resistance or dielectric strength. By combining a tantalum sheath, beryllium oxide insulation and tungsten/rhenium conductors, Continental Sensing has achieved a thermocouple accurate to 4000°F. Tungsten/rhenium thermocouples produce a relatively high EMF and are extremely sensitive to temperature change.

For accurate temperature measurement to 3000°F in oxidizing atmospheres, Con-O-Pak provides thermocouples with platinum/platinum rhodium conductors and beryllium oxide insulation in a platinum/rhodium sheath. Calibration curves are available for all noble metal thermocouple combinations.

Con-O-Pak thermocouples cover the complete temperature range from —268°F to +4000°F. They are available in diameters from .025" to .312" and with a wide variety of junctions and terminations.

REPRESENTATIVES: Many desirable areas are open for those with experience to represent our rapidly growing company in electronic and chemical fields.

STAFF PERSONNEL: If you are interested in joining our staff and have experience in electronic engineering or production, please write—or see us in Booth 728 at the I.S.A. Show in New York.

NEW! Con-O-Pak Stripper Kit for rapid hand baring of metallic sheathed thermocouple wire from .025" to .250" O.D. Complete with 6 heads and 5 extra precision ground tool bits.

Write for full information . . . "The Con-O-Pak Story" gives construction details and quality. Data sheets give specs and application data.

CON-O-PAK®

CONTINENTAL SENSING, INC.

1950 North Ruby Street, Melrose Park, Illinois

FLEXIBLE AND SHEATHED THERMOCOUPLES • THERMOCOUPLE WIRE • HEATING ELEMENTS • CONNECTORS

CIRCLE 175 ON READER-SERVICE CARD

New Industrial INFRARED Device...

THERMODOT® Radiation Thermometer Measures, Controls Temperature... Without Contact

THERMODOT is now being used in the production and testing of paper, glass, rubber, metals, and plastics. Designed for production plant operation, THERMODOT measures and controls the temperature of moving and inaccessible surfaces. Operation is remote, automatic, continuous.

High sensitivity provides reliable temperature measurements, even at low temperatures—lowest standard range 180-400°F full scale. Standard ranges extend to 4000°F. Standard response time is 2 seconds; 0.5 second available. An internal calibration source provides simple, rapid and accurate standardization.

THERMODOT measures the temperature of a remote object without physical contact. Operation is based on the fact that an object emits thermal radiation as a function of its temperature. An infrared lens, located in the THERMODOT optical head, is used to focus this radiation onto a sensitive infrared detector. The detector generates a signal voltage accurately proportional to the radiation intensity, and the signal is amplified to drive an indicator calibrated directly in temperature.

The THERMODOT radiation thermometer consists of an optical head and a power supply unit. THERMODOT is normally supplied with an indicator, indicating controller, or recording potentiometer. The optical assembly is housed in a sturdy, dust-tight enclosure and is insensitive to vibration and shock as normally encountered in the plant. Ambient temperature variations from 50-120°F have no effect on its operation.

SPECIFICATIONS OF THERMODOT MODEL TD-3

Working Distance ... Any range greater than one foot (prefocused at factory).

Speed ... Responds in 0.5 second.

Calibration ... Internal reference source for accurate standardization in seconds.

Emissivity Compensation ... Adjustable at control panel.

Ambient Conditions ... Unaffected by ambient temperature variations from 50-120°F.

For more information, write for Bulletin R-102, or see Thermodot operate at Booth No. 2018, ISA Exhibit, Sept. 26-30 in New York City.

RADIATION ELECTRONICS CO.

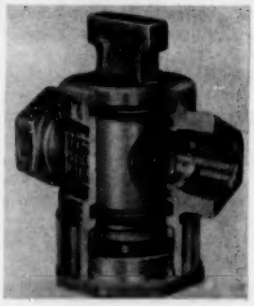
Dept. C-8 • 5600 Jarvis Avenue • Chicago 48, Illinois • Telephone: SPring 5-2400

DIVISION OF **COMPTOMETER** CORPORATION

INFRARED COMPONENTS • INSTRUMENTS • SYSTEMS

CIRCLE 176 ON READER-SERVICE CARD

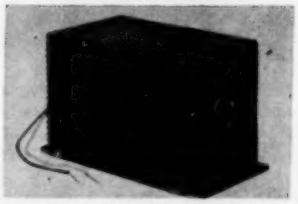
CURB VALVE



New line of Valves, marketed under the tradename Oriseal, constituting basically plug valves, features easy turning with virtual elimination of sticking and freezing of the plug. Top and bottom O-rings of equal size positively seal both ends of the plug. Sizes range from ¾" through 2", each with a working water pressure rating of 125 psig.—*Mueller Co., 512 West Cerro Gordo St., Decatur, Ill.*

CIRCLE 362 ON READER-SERVICE CARD

D-C/A-C INVERTER



New DC to AC Inverter features an output wave form that is a sine wave, with a maximum distortion of 5%, which can work into a wide range of leads from 0 to full output. Output voltage varies with input voltage if this inverter is not used with a transistorized regulator. Regulators are offered for use in this connection. —*Freed Transformer Co., Inc.*, 1718 *Weirfield St., Brooklyn (Ridgewood) 27, N. Y.*

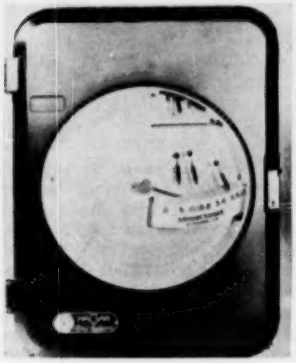
CIRCLE 363 ON RADER-SERVICE CARD

MINI PRESSURE TRANSDUCER

New Type 4-325 unbonded-strain-gage Pressure Transducer measures only ¾" in dia, ⅛" in height, and weighs only 8 gr. Pressure ranges are from 10 to 100 psia, 2 to 100 psig, and ±2 to ±50 psid. Rated and maximum excitation are 5 and 12 v rms. Carrier frequency is 0 to 20 kc.—*Consolidated Electrodynamics Corp., A subs. of Bell & Howell, 360 Sierra Madre Villa, Pasadena, Calif.*

CIRCLE 364 ON READER-SERVICE CARD

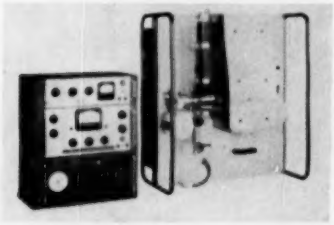
CONDUCTIVITY RECORDER



New 3-pen Conductivity Recorder-Indicator, whose basic system includes a conductivity recorder, a sampling cell, and a PowrLog Model H-O Receiver, employing 60-cycle excitation and a Wheatstone-bridge-type input circuit, evaluates the concentration of impurities in industrial steam-producing systems. The conductivity monitoring function can be combined with the Series 6000 Receiver in the same instrument producing a flow record where required as many as four conductivity receivers can be mounted in one instrument case, or three measuring functions such as temperature, pressure, and flow can also be provided in one instrument case.—*Hagan Chemicals & Controls, Inc., Hagan Center, Pittsburgh 30, Pa.*

CIRCLE 365 ON READER-SERVICE CARD

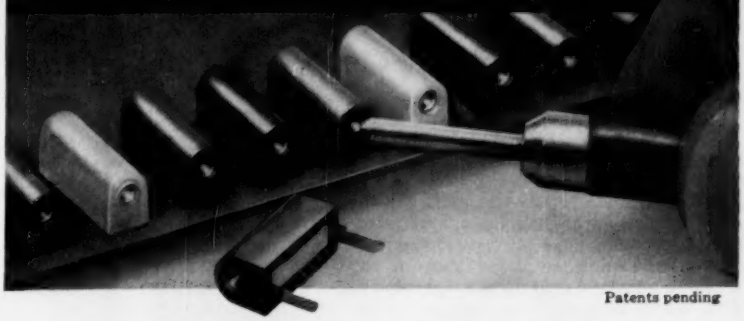
RADIOACTIVITY MONITOR



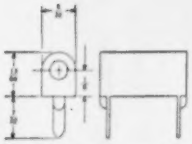
New Water Monitor continuously and automatically discovers radioactivity with such a sensitivity that it can measure activities due to Sr90 down to 5 x 10^{-9} μc/ml of water. It uses concentration procedures whereby the water to be tested is dosed in drips on to a continuously moving absorbent paper strip, where it is evaporated by a heating device. The band carries the residues of evaporation in front of one or several large surface scintallation counters. The installation consists of a detector and a measuring unit. Both units are connected by a scale and may be located at different points. The standard type contains a beta counter. Provisions are made for the addition of an alpha counter.—*Landis & Gyr, Inc., 45 West 45th St., New York 36, N. Y.*

CIRCLE 366 ON READER-SERVICE CARD

CHECK THE LOW COST of these new printed circuit test jacks



Patents pending



For .052 application holes on .400 centers

Samples on request

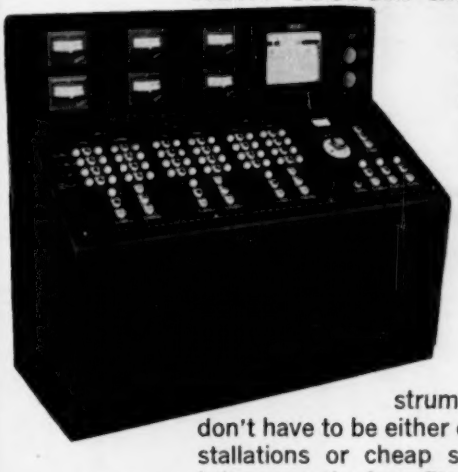
Ucinite's new test jack is designed for permanent, soldered assembly to printed circuit boards. Gold-over-silver-plated beryllium copper contacts provide low-resistance contact for repeated insertions of standard .080" diameter test probes. Nylon bodies are available in eleven standard code colors. Uniquely simplified construction affords economical usage in all quantities. Immediate shipments from stock.

ELECTRICAL DOT ASSEMBLIES

The UCINITE COMPANY
Division of UNITED-CARR Fastener Corporation
Newtonville 60, Massachusetts

CIRCLE 177 ON READER-SERVICE CARD

NEW! CUSTOM GRADE CONSOLES AT LOW STOCK PRICES!



GENCO CABINETS & PANELS

* fit your space exactly
* fit your equipment exactly
* protect costly, fragile instruments

Now consoles, instrument panels, cabinets don't have to be either expensive custom installations or cheap stock items. **GENCO** brings you the benefits of each . . . custom-made at little more than stock prices.

NEW BRUNSWICK GENERAL SHEET METAL WORKS
425 Cleveland Avenue, Highland Park, New Jersey
.....Rush my copy of new GENCO brochure.
..... Have your representative call.
Name.....
Company.....
Street.....
City.....Zone.....State.....

CIRCLE 178 ON READER-SERVICE CARD

MASSA
RECORDING SYSTEMS

ZERO BASED LINEARITY 1/4 MM
(40mm FULL SCALE)

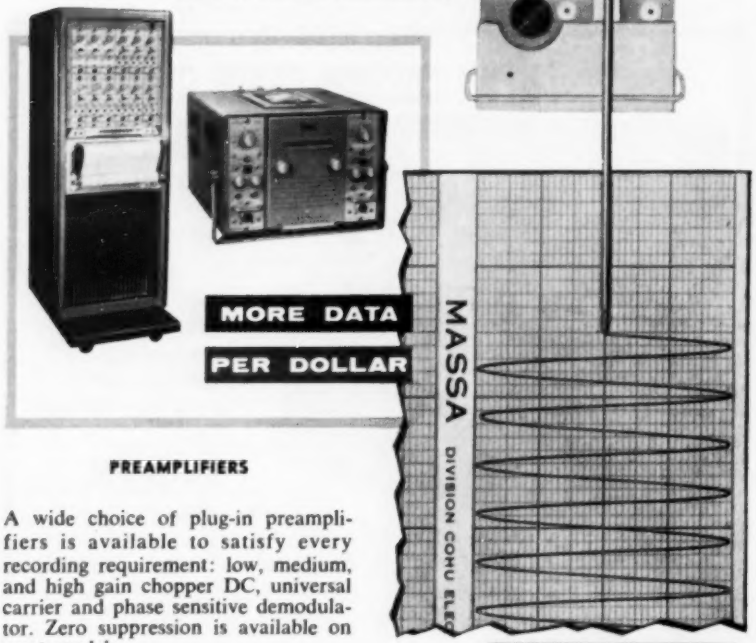
The lightweight, high-speed oscillograph Model OS-600 shown at the right is provided with INDIVIDUAL LINEARITY CONTROL ADJUSTMENTS for precisely setting the linearity at both extremes of deflections. This feature completely eliminates all errors due to inherent production variations in spring stiffness and magnetic field distribution near full scale amplitudes.

This rugged oscillograph, THE ONLY SOURCE FOR DIRECT RECTILINEAR INK WRITING, accurately records signals from DC to 120 cps. The electrodynamic drive system produces true rectilinear displacement of the pen tip. Electric writing can be effected by merely substituting an electric stylus for the ink pen.

LINEARITY CONTROL ADJUSTMENTS

PORTABLE AND MULTICHANNEL SYSTEMS

Available in 20 mm amplitude for rise time resolution of a few milliseconds, and 40 mm amplitudes. Individual transistorized driver amplifiers and power supplies for each channel designed to operate with frequency compensation either in or out.



PREAMPLIFIERS

A wide choice of plug-in preamplifiers is available to satisfy every recording requirement: low, medium, and high gain chopper DC, universal carrier and phase sensitive demodulator. Zero suppression is available on most models.

WESCON Booth Nos. 557-558

OTHER MASSA PRODUCTS

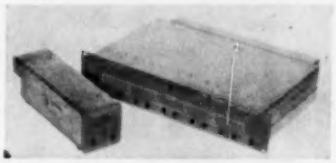
ACCELEROMETERS — MICROPHONES
TRANSDUCERS — HYDROPHONES
AMPLIFIERS
COMPLETE LINE OF MULTI-CHANNEL AND PORTABLE RECORDING SYSTEMS

MASSA
A DIVISION OF
COHU
ELECTRONICS, INC.

9 FOTTLER RD.
HINGHAM, MASSACHUSETTS

CIRCLE 179 ON READER-SERVICE CARD

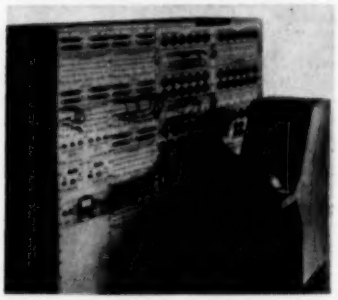
HIGH-SPEED COMPUTER



New Dystac Dynamic Storage Analog Computer featuring high-speed repetitive operation and dynamic memory, provides complex sequential reiterative calculations with an accuracy of ±0.05%. This permits stepwire control of a process unit (such as a distillation column) bringing it onstream, running it, then gradually removing the charge and taking the unit out of operation. Optimization of a process can be done economically from day-to-day within two or three minutes for a large number of variables. Many transient and difference-differential problems can be solved by the employment of continuous memory. A good example of such a problem is that encountered in the viscous-flow polymerization reactor. The basic unit is available with 46 amplifiers, field-expandable to 70 operational amplifiers. Large systems are equipped with 222 operational amplifiers, 90 electronic multipliers, and 30 ten-segment diode function generators.—*Computer Systems, Inc., (formerly Mid-Century Corp.) Culver Rd., Monmouth Junction, N. J.*

CIRCLE 367 ON READER-SERVICE CARD

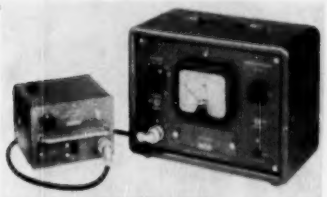
REPETITIVE ANALOG COMPUTER



New high-speed (compressed-time-scale) Analog Computer operates with an integrator sensitivity of 3000 v/sec and a repetitive mode continuously variable from 5 to 60 solutions/sec. Of paramount importance is the operating bandwidth which is at least 100 times wider than the present commercial specifications for analog computer amplifiers. New advancements of the computer include: All forcing functions and initial conditions are applied electronically and do not depend on travel time of electromechanical devices, additional gain and bandwidth stability, instantaneous overload indication, and recovery. —*GPS Instrument Co., Inc.*, 180 *Needham St., Newton, Mass.*

CIRCLE 368 ON READER-SERVICE CARD

ELECTROMETER



New Model 33C Vibron Industrial Electrometer (made by Electronic Instruments Ltd., England) with Model B33C Converter Unit is a special type of vibrating-capacitor electrometer suitable for industrial applications. Model 33C is a high-gain amplifier; Model B33C contains the vibrating capacitor unit together with pre-amplifier and input resistors. Input ranges are 10, 30, 100, 300, and 1000 mv. Current measurements as low as 10^{-15} amps are possible. Resistance measurements as high as 10^{16} ohms can be made. A feature of the instrument is its great zero stability which is ±100 mv for a 12-hr period, or ±300 mv for one week when fully stabilized. Accuracy of the instrument as a millivoltmeter is ±1% on all ranges. Bulletin 1038 gives details.—*Herman H. Sticht Co., Inc., 27 Park Pl., New York 7, N. Y.*

CIRCLE 369 ON READER-SERVICE CARD

GAS CHROMATOGRAPH

New Gas Chromatograph, utilizing tape programming for the first time to achieve greater precision and flexibility in automatic process control, employs a motor-driven 16-mm film in conjunction with a photoelectric transmitter and receiver to achieve any combination of time and sequence required in process chromatography. Accuracy of the tape-programmed timing system is reported to be greater than conventional mechanical cam timers. Repeatability approaches 0.1 sec. A three-position function switch allows the operator to choose either a bar-graph or a spectrum presentation of the complete chromatogram on the recorder chart, or manual operation in which the automatic tape programmer is stopped and the operator advances the sequence by depressing a push button. —*Mine Safety Appliances Co., 201 N. Braddock St., Pittsburgh 8, Pa.*

CIRCLE 370 ON READER-SERVICE CARD

$$\Delta E_o = \frac{dE_o}{E_o} = \left[\frac{-1}{1+\frac{R_1 E_2}{R_2 E_1}}\right] \Delta R_1 + \left[\frac{-1}{1+\frac{R_2 E_1}{R_1 E_2}}\right] \Delta R_2$$

This equation relates operational amplifier accuracy to the error contribution in each of 2 coefficient resistors. It occurs on page 5 of our technical manual "Networks for Computers".

We manufacture resistors and networks that maintain **total** ΔE_o accuracy of ±0.005% when required. This performance includes the effects of:

- Initial Tolerance
- Long-term Aging
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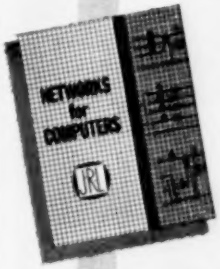

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Continuously Variable 1-30KV Unregulated DC Power Supply

A light, compact unit in wide use for insulation testing, condenser charging, precipitators and laboratory research. Polarity reversible from front panel. Current output: 2 ma. at 20KV; 1 milliampere at 30KV. Input: 117V AC 60 cycles. Dimensions: 19" x 10½" x 13". With meter installed on front panel ..... $275 Net
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For an output voltage of 5 KV DC at 1 milliampere, the low voltage input requirement is 250 V at 50 milliamperes. By varying the DC input the output voltage can be varied from approx. 1 KV to 7½ KV. Dimensions: 5⅝" high x 5" deep x 4¼" wide. In completely enclosed metal housing. $32.50 Net

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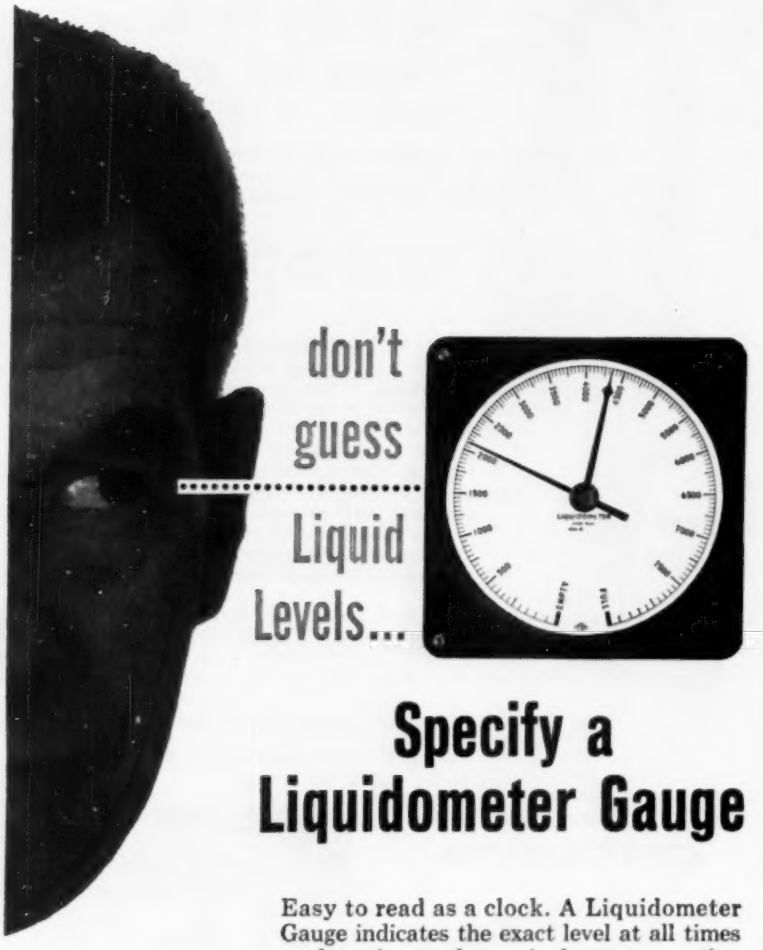

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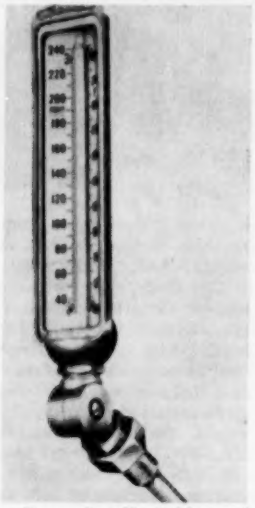
INDUSTRIAL THERMOMETERS



New line of adjustable-angle Industrial Thermometers assures accuracy and permanent reliability, as (1) they tilt or rotate to any angle, (2) a positive-locking universal joint permits adjusting instrument into desired position, (3) the capillary is totally enclosed, (4) a tapered bulb chamber, precision ground to 0.001" tolerance, contacts inner wall of separable sockets for sensitive, immediate response to temperature changes. Catalog 400 gives details.—*Moeller Instrument Co., 132nd St. & 89th Ave., Richmond Hill* 18, *N. Y.*

CIRCLE 371 ON READER-SERVICE CARD

REFRIGERATED AIR DRYER

New medium-capacity Model F-30 Refrigi-filter Air Dryer employs the principle of Freon-circulated closed loop refrigeration to cool compressed air to 40° at pressure. No prefilters or aftercoolers are necessary with this unit. Rated at 30 scfm at 100 psig, 100°F inlet air temperature, and 75°F ambient temperature, atmospheric dew points of −5°F are possible.—*Hankison Corp., College & Pike, Canonsburg, Penna.*

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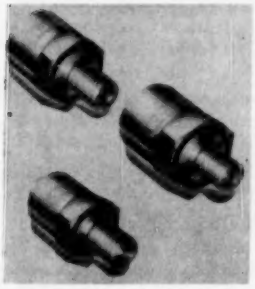
SHEATHED THERMOCOUPLES

New line of metal-sheathed thermocouples, a durable combination of sheath, wires, and ceramic insulation, features accuracy within the recommended ISA limits. Obtainable in a variety of configurations and standard cold end terminations.—*Harco Laboratories, Inc., New Haven, Conn.*

CIRCLE 373 ON READER-SERVICE CARD

ACCELEROMETERS



New line of self-generating Accelerometers features 500°F temperature operation and less than 3% cross-axis (lateral) sensitivity. First resonant frequency is 50 kc. Internal capacity is 1600 $\mu\mu f$. Maximum acceleration is 5000 G's—*Clevite Electronic Components, 3405 Perkins Ave., Cleveland 14, Ohio.*

CIRCLE 374 ON READER-SERVICE CARD

SEALED TIME TOTALIZER

New Type 620, a compact hermetically-sealed lightweight Elapsed Time Indicator accurately register up to 9,999.9 hours total operating or non-operating time for any type of electrically controlled equipment. Required operating power is 115v @ 60 cps (permanent-magnet synchronous type) or 400 cps (hysteresis-synchronous type).—*Cramer Controls Corp., Centerbrook, Conn.*

CIRCLE 375 ON READER-SERVICE CARD

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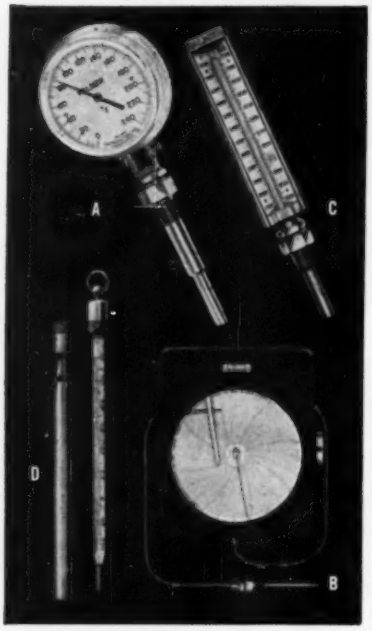

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C—INDUSTRIAL THERMOMETERS: Red-Reading Mercury—Extruded brass case—chrome finish. Ranges: —40 +950° or Equivalent in °C.

D—RED-READING MERCURY LABORATORY THERMOMETERS: Thoroughly annealed for permanent accuracy. Complete line A.S.T.M. and fractional division types.

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PANEL INSTRUMENTS

New series of 2½"-dia Panel Instruments, Model 25, for commercial applications features modern-style plastic case which requires no more space than ordinary meters, a self-shielding internal core magnet with greater torque, and external zero adjuster. Bulletin 25-560 contains details.—*DeJur-Amsco Corp., Electronics Div., 45-01 Northern Blvd., Long Island City 1, N. Y.*

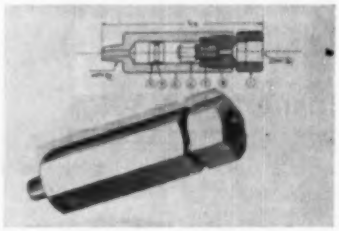
CIRCLE 376 ON READER-SERVICE CARD

PACKLESS VALVE

New Packless Valve, Type Demi-GS, features a resilient diaphragm which is able to withstand deformation by trapped impurities while still providing tight shut-off. Ideal for instrument air and other gas and liquid services, it is rated for 500 psig and will close with only 10 in-lb of torque at that pressure in dead end service. Furnished in brass with ¼" or ¼" NPT connections.—*George W. Dahl Co., Inc., 86 Tupelo St., Bristol, R. I.*

CIRCLE 377 ON READER-SERVICE CARD

FLOW CHECK SNUBBER



New Flow Check Snubber affords protection against escape of noxious, toxic, or flammable liquids or gases in the event of pressure instrument failure and prevents loss of product by completely isolating instruments from the pressure atuating medium. Full equilibrium is reached in just 2 to 3 se.—*Chemiquip Co., 36 East 10th St., New York 3, N. Y.*

CIRCLE 378 ON READER-SERVICE CARD

A familiar shape to DC amplifier devotees

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SLOW DC: K2-P gives to other dc amplifiers, such as K2-W and K2-XA, drift stability well under 1 millivolt, long term. This chopper stabilized unit has the same case structure and octal base as the K2-W and sells for **$60***

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CIRCLE 188 ON READER-SERVICE CARD

NEW LITERATURE

VALVES

REGULATING RELIEF VALVE. 2-page Catalog Section III describes with specs and dimensional sketch, No. 280, Type G valve.—Atlas Valve Co., 280 South St., Newark 5, N. J.
CIRCLE 379 ON READER-SERVICE CARD

MOTOR-ACTUATED VALVES. 16-page Condensed Bulletin 100 describes and illustrates electric motorized valves, and temperature regulators, pressure regulators, etc.—Warren Engineering Co., Div. of Warren Automatic Controls Corp., Route 24, Broadway, N. J.
CIRCLE 380 ON READER-SERVICE CARD

TEMPERATURE

METAL-SHEATHED TC's. 6-page gatefold Bulletin P1281A describes Armorox metal-sheathed, ceramic-insulation thermocouples.—Bristol Co., Waterbury 20, Conn.
CIRCLE 381 ON READER-SERVICE CARD

TEMPERATURE CONTROLLERS. 4-page Brochure MC-185A contains specs on thermistor probes and control instruments.—Fenwal Incorporated, Pleasant Street, Ashland, Mass.
CIRCLE 382 ON READER-SERVICE CARD

THERMAL MEASUREMENTS. 2-page Catalog Sheet T-60 describes resistance thermometer elements, instruments, bridges, radiometers, reference junctions, etc.—Arthur C. Ruge Associates, Inc. of New England, Hudson, N. H.
CIRCLE 383 ON READER-SERVICE CARD

FLOW, PUMPS, LEVEL

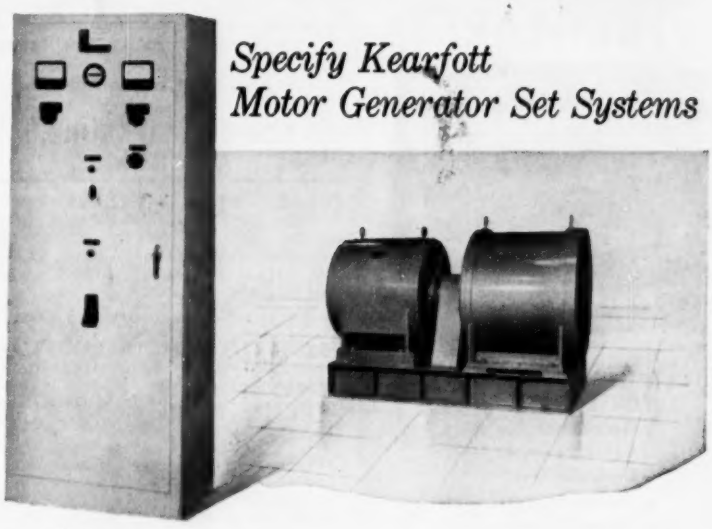
FLUID FLOW RATE ALARMS. 4-page Bulletin 175 gives details and examples of rotameter accessories to provide signalling and simple control functions.—Brooks Rotameter Co., Box 432, Lansdale, Penna.
CIRCLE 384 ON READER-SERVICE CARD

PROPORTIONING PUMPS. 8-page Catalog 100 describes Series 100 controlled-capacity pumps for chemical applications.—American Meter Co., Pump Div., 13500 Philmont Ave., Phila. 16, Pa.
CIRCLE 385 ON READER-SERVICE CARD

LEVEL CONTROLLERS. 16-page Composite Catalog 4-60 illustrates and describes equipment for liquid and granular solid level controls based on gamma-radiation, capacitance, electronic, pneumatic and mechanical principles.—Instruments, Inc., Box 556, Tulsa, Okla.
CIRCLE 386 ON READER-SERVICE CARD

FLOW INSTRUMENTATION. 8-page General Bulletin describes water- and waste-treatment equipment and systems, supervisory controls, differential- and displacement-meters, weighers, and blenders.—B-I-F Industries, Box 1342, Providence 1, R. I.
CIRCLE 387 ON READER-SERVICE CARD

FOR PRECISE 400-CYCLE POWER



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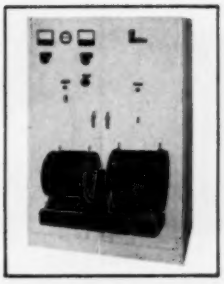
Kearfott 60-to-400 cycle motor generator frequency converters are in active use wherever precise 400-cycle power must be supplied . . . including laboratories and in such other representative applications as production testing, high speed tool operation and ground support. These generator systems, which consist of a 60 cycle synchronous motor and a 400 cycle generator, can be supplied with controls and generator as an integral, compact unit—or with controls and generator separately located.



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Frequency: 400 cycles under any rated load condition with 60 cycle input.

Voltage Regulation: Within ±1% of rated voltage when (1) load varies between no-load and 125% of rated load, and/or (2) load power factor varies between 0.8 lagging and unity, and/or (3) equipment temperature varies after approximately 10 minutes' operation.

Voltage Recovery: When rated load is suddenly applied or removed, voltage will return to and remain within regulating band within 0.25 seconds.

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Frequency Modulation: Maximum 0.5% at any load from no load to 125% of rated load.

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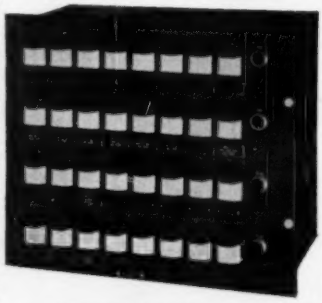

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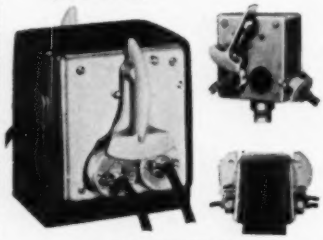

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ICS NEW LITERATURE

UNION CONNECTION VALVES. 2-page Data Unit 377 contains information on gages and valves for the observation of liquids and level featuring spherical union connections.—Jerguson Gage & Valve Co., 80 Adams St., Burlington, Mass.

CIRCLE 388 ON READER-SERVICE CARD

FORCE, PRESSURE, VACUUM

FORCE CONTROL SWITCHES. 6-page Bulletin 49-E describes line of force control switches which operate in compression or tension.—W. C. Dillon & Co., Inc., Box 3008, 14620 Keswick St., Van Nuys, Calif.

CIRCLE 389 ON READER-SERVICE CARD

PRESSURE/LEVEL TRANSMITTERS. 2-page Bulletin P-36-1 describes force-balance transmitter, Model P, and gives application examples.—Conoflow Corp., 2100 Arch St., Phila. 2, Pa.

CIRCLE 390 ON READER-SERVICE CARD

PRESSURE INSTRUMENTS. 4-page Short Form Catalog S-60-1 lists a wide range of pressure-operated instruments and rectilinear potentiometers.—Servonic Instruments, Inc., 640 Terminal Way, Costa Mesa, Calif.

CIRCLE 391 ON READER-SERVICE CARD

STRAIN GAGE INSTRUMENTATION. 6-page Brochure presents the Waldale products in the strain-gage field.—Lockheed Aircraft Corp., Electronics and Avionics Div., 6201 E. Randolph St., Los Angeles 22, Calif.

CIRCLE 392 ON READER-SERVICE CARD

IONIZATION GAGE CONTROLS. 2-page Data Sheet 563 contains description and specs of Models IG-50 and IG-60 for ultra-high vacuum measurements.—F. J. Stokes Corp., 5500 Tabor Rd., Phila. 20, Pa.

CIRCLE 393 ON READER-SERVICE CARD

TIME, COUNT

TIMERS AND COUNTERS. 28-page Condensed Catalog D-31 contains pictures and description of 14 series of timers, also test equipment, switches, controllers, contactors, valves, differential transmitters, etc.—Automatic Timing & Controls, Inc., King of Prussia, Penna.

CIRCLE 394 ON READER-SERVICE CARD

TIMING DEVICES & CONTROLS. 6-page Product Bulletin 5907 describes and illustrates sequence timers, flashers, inter-valometers, programmers, pulse-train generators, repeat cycle timers, etc.—Tempo Instrument Inc., Box 338, Hicksville, L. I., N. Y.

CIRCLE 395 ON READER-SERVICE CARD

PROGRAMMERS. 8-page Bulletin 82057 describes programmers with systems applications.—Harold Beck Co., 3640 N. Second St., Phila. 40, Pa.

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TIME-SPEED RECORDER. 2-page Bulletin TS-60 describes time-speed recorder designed to detect hidden trouble in machine operations and processes.—R. B. Annis Co., 1101 N. Delaware St., Indianapolis 2, Ind.
CIRCLE 397 ON READER-SERVICE CARD

MICRO-MINI SEQUENCE TIMER. 2-page data sheet contains description and constructional features of timer designed specifically for rocket, missile, and satellite use.—Acton Labs., Inc., Space Instrumentation Div., Sub. of Technology Instrument Corp., 533 Main St., Acton, Mass.
CIRCLE 398 ON READER-SERVICE CARD

VIBRATION

VIBRATION TRANSDUCER. 2-page Bulletin 1628 specifies Type 4-123A, with description of construction and application.—Consolidated Electrodynamics Corp., 360 Sierra Madre Villa, Pasadena, Calif.
CIRCLE 399 ON READER-SERVICE CARD

RESONANT MODE PHOTOGRAPHY. 2-page Application Bulletin 5A describes a unique method for obtaining photography of vibrations.—Chadwick-Helmuth Co., 427 E. Duarte Rd., Monrovia, Calif.
CIRCLE 400 ON READER-SERVICE CARD

AIR, GAS

GAS TEST METERS. 6-page Catalog T/47 contains capacity, dimensions, accuracy, etc. on 4 types wet meters, and 4 types dry meters.—Instrumentation Associates, 17 West 60th St., New York 23, N. Y.
CIRCLE 401 ON READER-SERVICE CARD

AIR CLEANER. 8-page Bulletin describes the Aridifier, a mechanical cleaner for compressed-gas and air lines.—Logan Engineering Co., 4901 W. Lawrence Ave., Chicago 30, Ill.
CIRCLE 402 ON READER-SERVICE CARD

MICRO-PROCESSING EQUIPMENT. 4-page Bulletin MP-1 illustrates and describes units for removing solids, liquid, or vapor contaminants from fluid systems.—Selas Corp. of America, Dresher, Penna.
CIRCLE 403 ON READER-SERVICE CARD

DATA HANDLING

MOBILE TAPE RECORDER. 4-page Bulletin DD-5 describes and explains uses of Model 3116, said to have the accuracy of a lab tape system.—Minneapolis-Honeywell Regulator Co., Industrial Systems Div., 10721 Hanna St., Beltsville, Md.
CIRCLE 404 ON READER-SERVICE CARD

COMPUTER APPLICATION. 8-page LGP-30 Application Report 16 describes how a LGP-30 was used for refinery design.—Royal McBee, Data Processing Div., Port Chester, N. Y.
CIRCLE 405 ON READER-SERVICE CARD

PULSE WIDTH SELECTION SYSTEM 6-page technical brochure explains operation and application of the PWS system.—Hammarlund Mfg. Co., Inc., 460 West 34th St., New York 1, N. Y.
CIRCLE 406 ON READER-SERVICE CARD

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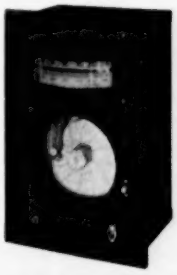
STEPLESS Controllers (Model JSB) infinitely modulate electric heat. No on-off pulses. Prolongs heater-life, saves power. Exclusive manual switch, adjustable maximum and minimum input control. *Tubeless.* Compact. Least maintenance and operating attention required.



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ICS NEW LITERATURE

INDUSTRIAL TELEMETERING. 8-page brochure gives features of Ascop telemetry system with detailed specifications.—Electro-Mechanical Research, Inc., Ascop Div., Princeton, N. J.

CIRCLE 407 ON READER-SERVICE CARD

ANALOG COMPUTER. 6-page Bulletin AC 6013 describes with pictures design features of the Pace 221 R low-cost computer.—Electronic Associates, Inc., Long Branch, N. J.

CIRCLE 408 ON READER-SERVICE CARD

HIGH-SPEED COMPUTER. 4-page Folder F-10 describes Model PDP-1 programmed data processor, and gives basic instructions.—Digital Equipment Corp., Maynard, Mass.

CIRCLE 409 ON READER-SERVICE CARD

LANGUAGE TRANSLATORS. 4-page leaflet describes the universal tape-to-tape translator.—Computer Control Co., Inc., 983 Concord St., Framingham, Mass.

CIRCLE 410 ON READER-SERVICE CARD

HI-SPEED RECORDERS. Folder contains eight 2-page bulletins on recorders, printers, analyzers, etc.—Hogan Faximile Corp., 155 Perry St., New York 14, N. Y.

CIRCLE 411 ON READER-SERVICE CARD

TELE-SCAN RECORDING SYSTEMS. 4-page Bulletin 210 describes system for transmitting data to distant computer facilities via standard telephone circuits.—Daystrom, Inc., Control Systems Div., Miramar Rd., LaJolla, Calif.

CIRCLE 412 ON READER-SERVICE CARD

MINIMODULE ENCODER. 2-page Bulletin 124 specifies and describes 10-bit binary encoder with built-in logic.—Datex Corp., 1307 S. Myrtle Ave., Monrovia, Calif.

CIRCLE 413 ON READER-SERVICE CARD

RECORDERS

RECORDER RANGE CHANGING. 4-page Data Sheet NY2(1) "Speedomax H Range Conversion," is a guide for the selection of scale, chart, circuit panel, etc. to change the range of any standard Speedomax H instrument.—Leeds & Northrup Co., 4934 Stenton Ave., Phila. 44, Pa.

CIRCLE 414 ON READER-SERVICE CARD

OSCILLOGRAPH. 2-page Bulletin 580-4860 contains features and specs of Model 580 oscillograph.—Midwestern Instruments, Box 7186, Tulsa 18, Okla.

CIRCLE 415 ON READER-SERVICE CARD

OPERATION RECORDERS. 4-page Bulletin 660 describes applications of operation recorders.—Esterline-Angus Co., Box 596, Indianapolis 6, Ind.

CIRCLE 416 ON READER-SERVICE CARD

TESTING

FLAW DETECTOR. 8-page Bulletin T200 describes ultrasonic flaw detection with the Sonoray, Model 5.—Branson Instruments Inc., 40 Brown House Rd., Stamford, Conn.

CIRCLE 417 ON READER-SERVICE CARD

TESTING INSTRUMENTS. 68-page Manual C-61 contains 22 bulletins and price lists on insulation, high-potential, corona, resistance testing, etc.—Associated Research Inc., 3758 West Belmont Ave., Chicago 18, Ill.

CIRCLE 418 ON READER-SERVICE CARD

ELECTRONIC TEST INSTRUMENTS. 20-page Catalog 28/Industrial contains illustrations and specs of volt-ohm-milliammeters, VTV's, tube and transistor testers, oscilloscopes, signal generators, etc.—Precision Apparatus Co., Inc., 70-31 84th St., Glendale 27, L. I., N. Y.

CIRCLE 419 ON READER-SERVICE CARD

HI-VOLTAGE TEST EQUIPMENT. Short Form Catalog 60 contains pictures and tabulations of hipot testers, overpotential testers, corona test sets, pinhole detectors, etc.—Peschel Electronics, Inc., Towners, Patterson, N. Y.

CIRCLE 420 ON READER-SERVICE CARD

CONTROL AND TEST EQUIPMENT. 8-page catalog describes equipment for checkout and validation of airborne or ground electrical, electronic, or electromechanical systems.—Pacific Automation Products, Inc., 1000 Air Way, Glendale 1, Calif.

CIRCLE 421 ON READER-SERVICE CARD

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CIRCLE 194 ON READER-SERVICE CARD

TEST CHAMBERS. 2-page bulletin reviews CO_2-cooled chambers operating from −100 to +600°F.—Gruenberg Electric Co., Inc., 9 Commercial Ave., Garden City, N. Y.

CIRCLE 422 ON READER-SERVICE CARD

TEST INSTRUMENTS. 28-page catalog contains pictures and detailed description of stereo and mono high-fidelity test instruments.—Electronic Instrument Co., Inc., 33-00 Northern Blvd., Long Island City 1, N. Y.

CIRCLE 423 ON READER-SERVICE CARD

ELECTRICAL, ELECTRONIC INSTRUMENTS

ELECTRICAL METERS. 2-page leaflet describes the bifilar suspension principle used in ammeters, voltmeters, thermocouple meters, megohmmeters, etc.—Greibach Instruments Corp., 315 North Ave., New Rochelle, N. Y.

CIRCLE 424 ON READER-SERVICE CARD

OSCILLOSCOPE. 4-page pamphlet gives a detailed presentation of the transistorized, battery-operated, portable Type 321 oscilloscope.—Tektronix, Inc., Box 500, Beaverton, Ore.

CIRCLE 425 ON READER-SERVICE CARD

POWER SUPPLIES. 32-page Handbook contains technical data, as well as illustrations and specifications of d-c power supplies, inverters and converters, line-voltage regulators, etc.—Sorensen & Co., Inc., a sub. of Raytheon Co., Richards Ave., South Norwalk, Conn.

CIRCLE 426 ON READER-SERVICE CARD

INFRARED RADIATION. 2-page Bulletin TB 1300-60 describes and specifies infrared detector preamplifiers.—Servo Corp. of America, 111 New South Rd., Hicksville, L. I., N. Y.

CIRCLE 427 ON READER-SERVICE CARD

SOLID-STATE CIRCUITS. 4-page brochure illustrates and describes power supplies, ground support equipment, advanced solid-state circuit equipment, industrial control systems, etc.—Pennon Electronics, Inc., 7500 So. Garfield, Bell Gardens, Calif.

CIRCLE 428 ON READER-SERVICE CARD

ELECTRICAL INSTRUMENTS. 4-page Short Form Catalog illustrates and tabulates signal generators, frequency meters, Q-meters, bridges, power meters, pulse generators, wave analyzers, oscilloscopes, etc.—Marconi Instruments, 111 Cedar Lane, Englewood, N. J.

CIRCLE 429 ON READER-SERVICE CARD

ELECTRONIC PRODUCTS. 288-page General Catalog contains three sections of electron tubes, electronic instruments and industrial systems, and microwave instruments.—Hoffman Electron Tube Corp., 804 Newbridge Ave., Westbury, L. I., N. Y.

CIRCLE 430 ON READER-SERVICE CARD

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Output	20 Watts
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No Load Speed	3500 R.P.M.
Inertia (Wk2)	.725 oz. in.^{2}
Theor. acceleration	13,300 rad/sec.^{2}
Weight	2.75 lbs.
Motor Transfer Function	$\frac{3.2}{S\ (.028S + 1}$
Frequency response	5.75 cyc./sec

Write for more information on our complete line of instrument servomotors. Available in sizes 11 and 15, power ratings from 1 to 20 watts.

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CIRCLE 195 ON READER-SERVICE CARD

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(TUBING BUNDLES)

POLYETHYLENE TUBES ENCLOSED IN VIRGIN PVC (VINYL) SHEATH

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Tubing — ¼" O.D. x .040" Wall, .045" or .062" Sheath

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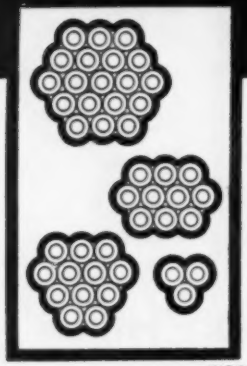

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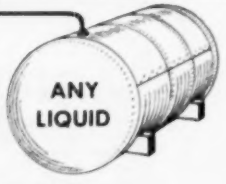

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CIRCLE 198 ON READER-SERVICE CARD

ICS NEW LITERATURE

APPLICATION NOTES. 2-page bulletin is an index of some 40 application notes which describe electronic theory, measurements, and applications of electrical instruments.—Hewlett-Packard Co., 1501 Page Mill Rd., Palo Alto, Calif.

CIRCLE 431 ON READER-SERVICE CARD

DIGITAL VOLTMETER. 2-page specification sheet contains pictures and specifications of Model V-1 which converts unknown voltages into digital numbers.—Electro-Logic Corp., 515 Boccaccio Ave., Venice, Calif.

CIRCLE 432 ON READER-SERVICE CARD

ELECTRICAL, ELECTRONIC COMPONENTS

ELECTRICAL SYSTEMS CABINETS. 2-page Product Specification G71-6 details construction, wiring, and dimensions of cabinets for system design and packaging.—Bailey Meter Co., 1050 Ivanhoe Rd., Cleveland 10, Ohio.

CIRCLE 433 ON READER-SERVICE CARD

FREQUENCY COUNTERS. 4-page Condensed Catalog File No. 605 illustrates and tabulates specs of counters, accessories, readouts, frequency standards, decades, etc.—Northeastern Engineering, Inc., Manchester, N. H.

CIRCLE 434 ON READER-SERVICE CARD

SUB-MINI TEFLON TERMINALS. 20-page bulletin contains dimensional drawings and tabulations of standoffs, feed-thrus, jacks and plugs, etc. —Tri-Point Plastics, Inc., Albertson, L. I., N. Y.

CIRCLE 435 ON READER-SERVICE CARD

CRYSTAL TRANSDUCERS. 4-page Data Folder 101160 outlines uses, properties, and advantages of natural quartz pressure-sensitive crystal transducers.—Kistler Instrument Corp., 15 Webster St., North Tonawanda, N. Y.

CIRCLE 436 ON READER-SERVICE CARD

FIBERGLASS SLEEVING. 4-page bulletin describes properties of Hygrade Thermoflex Class C insulation sleeving.—L. Frank Markel & Sons, Norristown, Penna.

CIRCLE 437 ON READER-SERVICE CARD

MISCELLANEOUS

PHOTO EQUIPMENT & INSTRUMENTATION. 132-page Catalog 459-S contains pictures and descriptions of hundreds of photographic items from cameras and enlargers to lenses, etc. —Burke & James, Inc., 321 South Wabash Ave., Chicago 4, Ill.

CIRCLE 438 ON READER-SERVICE CARD

ATMOSPHERE RESISTANCE ALLOY. 8-page Bulletin 110 presents physical properties, life- and temperature-resistance curves, etc. on Chromel-AA alloys.—Hoskins Mfg. Co., 4445 Lawton Ave., Detroit 8, Mich.

CIRCLE 439 ON READER-SERVICE CARD

SUPERVISORY CONTROL. 4-page Bulletin CP-3708 describes Varelectric 880 series controls for valves, pumps, and any electrically operated equipment, with list of available models, and specifications.—Vapor Recovery Systems C., 2820 No. Alameda St., Compton, Calif.

CIRCLE 440 ON READER-SERVICE CARD

IMPERVIOUS GRAPHITE PIPE. 12-page Bulletin 965-2 contains description, pictures, and dimensions of armored and non-armored piping.—Falls Industries, Inc., Solon, Ohio.

CIRCLE 441 ON READER-SERVICE CARD

CLOSED CIRCUIT TV CAMERA. 4-page Bulletin ECL 85 provides descriptive information on transistorized industrial TV camera, Type TE-9-A.—General Electric, Communication Products Dept., Box 4197, Lynchburg, Va.

CIRCL 442 ON READER-SERVICE CARD

CENTRIFUGES. 4-page brochure is an illustrated guide to centrifuges and instruments for physical chemistry.—Ivan Sorvall, Inc., Norwalk, Conn.

CIRCLE 443 ON READER-SERVICE CARD

COMMUNICATION EQUIPMENT. 6-page Engineering Bulletin 66 describes capabilities, facilities, personnel, and products.—Rixon Electronics, Inc., 2414 Reedie Dr., Silver Spring, Md.

CIRCLE 444 ON READER-SERVICE CARD

MEDICAL APPARATUS. 4-page brochure illustrates and describes several types of lung-function apparatus made by Godart-Mijnhardt NV, Holland.—Instrumentation Associates Inc., 17 West 60th St., New York 23, N. Y.

CIRCLE 445 ON READER-SERVICE CARD

PATENTS FOR INVENTORS. 20-page booklet "Preparing for Patent-hood," a booklet about patents for inventors and engineers, is interspersed with cartoons to illustrate the point.—Trak Electronics Co., Div. of CGS Labs., Inc., 49 Danbury Rd., Wilton, Conn.

CIRCLE 446 ON READER-SERVICE CARD

ABSOLUTE LEVEL CONTROL. 2-page Bulletin 60-05 describes application of Serva-Levl to maintain absolute level of lathes despite changing load conditions.—Barry Controls Inc., 700 Pleasant St., Glendale, Calif.

CIRCLE 447 ON READER-SERVICE CARD

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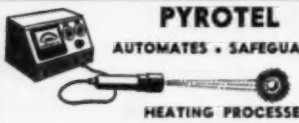

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- NEW: Air Operated Small Head WHD 4AP and Precision AC and Stored Energy Power Supplies

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SHAFT SPEEDS CUTTING SPEEDS SURFACE SPEEDS

- **Magnetic Design** Steady readings accurate to ±0.5%
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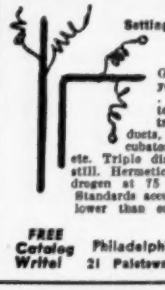
Fixed Set Thermostats



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Setting Range: —55°C to 370°C
Set Sensitivity: ±.01°C

Guaranteed sensitivity . . . year-in, year-out reliability . . . accurate control of temperature in ovens, electronic equipment, baths, ducts, freezers, fire alarms, incubators, analytic instruments, etc. Triple distilled mercury; filled at still. Hermetically sealed with dry hydrogen at 75 psi. Calibrated to Bur. Standards accuracy. Priced 10% to 15% lower than competitive lines.

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NEW MODEL G THERMAL WIRE STRIPPER

Strips both Teflon and low-melting plastics.
No blades to cut or nick wire.
Has continuously-variable heat control.
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BRM TELEMETER TRANSMITTER

use with most PDM telemeter receivers (B.I.F. Chronoflo, Bristol Metameter, etc.)

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Model HT-12 Four-Range Tachometer

Centrifugal tachometer that measures revolutions per minute and surface speeds.

TOTAL RANGE: 90-12,000 RPM
1st — 90-360 RPM
2nd — 300-1200 RPM
3rd — 900-3600 RPM
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Feet per minute—one half the dial reading with use of 6" disc wheel.
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Advantages: Accuracy—±0.5% • Stop button feature • Instantaneous readings • 3" easy to read dial • Light—approx. 14 oz.

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CIRCLE 208 ON READER-SERVICE CARD

PEOPLE IN THE NEWS

MARION INSTRUMENT DIV. of M-H announces appointments of *Edward S. Maury* as vice president in charge of engineering and of *Kenneth J. Cumming* as marketing manager.

E. S. Maury
Marion Div.

K. J. Cumming
Marion Div.

K. W. Premo
Robertshaw

L. T. Garnett
Robertshaw

ROBERTSHAW AERONAUTICAL DIV. has appointed *Kenneth W. Premo* field engineer and *Lawrence T. Garnett* senior development engineer.

COMPUTER MEASUREMENTS CO. has named *Austin F. Marx* sales manager.

INFORMATION SYSTEMS announces that *Doane R. Gero* has been appointed president.

A. F. Marx
Computer Meas.

D. R. Gero
Information Sys.

J. G. Roback
EPSCO

EPSCO INC. announces that *Jack G. Roback* has been appointed general sales manager of the new subsidiary **MONITOR SYSTEMS, INC.**

GULTON INDUSTRIES reports acquisition of **SYSTEMS RESEARCH GROUP. AVIEN, INC.** has acquired **ELECTROL, INC.**

DAYSTROM, INC. has acquired the assets of **WIANCKO ENGINEERING CO.**

THE BRISTOL COMPANY, a subsidiary of American Chain & Cable Co., has acquired **HANSON-GORRILL-BRIAN** and will operate the business through a new subsidiary **DATA-MASTER CORP.**

COMPUTER SYSTEMS, INC. has occupied its new 30,000-sq-ft plant at Monmouth Junction, N. J.

JAMES M. SCOTT

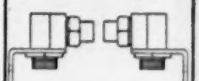
James M. Scott, general plant manager and treasurer of Scott Testers, Inc., suddenly died at the age of 50 from a heart attack. He was vacationing on his cabin cruiser when he was fatally stricken.

FRANK V. LONG, SR.

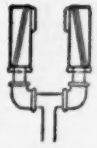
Frank V. Long, Sr., 60, president of Vapor Recovery Systems Co., died June 27 after suffering from a heart ailment for the last three years.

Widely known in the petroleum and chemical fields, Mr. Long had founded the company in 1928.

Remote Heads for Small Space



E8A-E8AP Remote heads with special mounting bracket



E1A-
E1AP

Compact, rugged—easily positioned remote heads. Available with ¾" diameter straight beam—also fixed focus pin point beam.

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I&CS ADVERTISERS' INDEX

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ARCCO Instrument Company, Inc. 1392
American Chain & Cable Company, Inc., Helicoid Gage Division 1412
American Measurement & Control, Inc. 1302
American Meter Company, Incorporated 1281, 1283
American Optical Company 1366
Amperite Co. Inc. 1256
Annin Company 1261
Assembly Products, Inc. 1247
Associated Research, Incorporated 1435
Automatic Electric 1345
Automatic Timing & Controls, Inc. 1374
Autotron, Inc. 1435

BRM Meter Co. 1434
Bailey Meter Company 1342, 1343
Barber-Colman Company, Wheelco Instruments Div. 1389
Barton Instrument Corporation 1257
Bell & Gossett Company 1245
Bendix Corporation 1352
Benson-Lehner Corporation 1264
Bird & Co., Inc., Richard H. 1402
Bridgeport Thermostat Division, Robertshaw-Fulton Controls Co. 1258, 1259
Bristol Company 1253, 1270, 1271
Brooks Rotameter Company 1403
Brush Instruments Division of Clevite Corporation 1251, 1252
Burgess Battery Company 1262
Burroughs Corporation, Electronic Tube Division 1425

Chicago Dynamic Industries, Inc. 1401
Chrono-Log Corporation 1372
Clevite Corporation, Brush Instruments Division 1251, 1251
Compact Circuits Company, Division of Electrons Incorporated 1357
Computer Measurements Co. 1223
Computer Systems, Inc. 1300
Conoflow Corporation 1242, 1243
Consolidated Electrodynamics 1234
Continental Sensing, Inc. 1419
Crawford Fitting Company 1267
Crescent Insulated Wire & Cable Co., Inc. 1387
Crystal Glass Tube & Cylinder Co. 1430
Curtiss-Wright Corporation, Princetone Division 1398

Dahl Company, Inc., George W. 1400
DeJur-Amsco Corporation 1244
Delavan Manufacturing Company 1385
DeZurik Corporation 1383
Diehl Manufacturing Company 1431
DuMont Laboratories, Inc., Allen B. 1228
DuPont de Nemours & Co., E. I. 1289
Dynametrics Corporation 1399

ESCO Eng. & Mfg. Corp. 1397
Edison Industries, Thomas A. 1409, 1411, 1413
Edwards Company, Inc. 1241
Eldorado Electronics 1410
Electro-Mech Corp. 1276, 1277
Electronic Associates, Inc. 1292
Emery Company, A. H. 1376
Engelhard Industries, Inc. 1348, 1349
Epic Inc. 1401
Eppley Laboratory, Inc. 1405
Epsco-West a Division of Epsco Inc. 1310
Erie Pacific Div. of Erie Resistor Corp. 1368
Erwood, Inc. 1416
Esterbrook Pen Company 1285
Esterline-Angus Company 1282
Ewald Instruments 1434
Exactel Instrument Company 1396
Electro Instruments, Inc. ..... Back Cover

Fisher Governor Company 1291
Foxboro Company 1239, 1246
Freed Transformer Co., Inc. 1434

GPE Controls, Inc. ..... Inside Front Cover
GPS Instrument Co. Inc. 1299
General Controls Co. ..... Inside Back Cover
General Electric Company 1370, 1371
General Kinetics Corp. 1415
General Motors Corporation, New Departure Division 1236
Gould Co., J. D. 1399
Graphic Controls Corporation 1391
Green Instrument Co., Inc. 1399
Greibach Instruments Corporation 1231
Gubelman Charts Incorporated 1403

Hagan Chemicals & Controls, Inc. 1381
Hankison Corporation 1226, 1227
Harco Laboratories, Inc. 1408
Hays Corporation 1229
Heise Bourdon Tube Company, Inc. 1417
Helicoid Gage Division, American Chain & Cable Company, Inc. 1412
Hoskins Manufacturing Co. 1230

Ideal Industries, Inc. 1260
Illinois Testing Laboratories, Inc. 1321, 1322
Imperial Brass Mfg. Co. 1273
Industrial Electronic Engineers, Inc. 1416
Industrial Instruments Inc. 1224, 1225
InstruLab, Inc. 1432
Instrument Development Laboratories, Inc. 1388

Jamesbury Corp. 1274
Jerguson Gage & Valve Company 1436
Johnson-Williams, Inc. 1404
Jones Optical Works, A. D. 1399
Judson Bigelow Sales Division, Techni-Rite Electronics Inc. 1397
Julie Research Laboratories, Inc. 1423

Kanthal Corporation 1397
Kearfott Division General Precision, Inc. 1427
Kernco Instruments Co., Inc. 1434
Krohn-Hite Corporation 1414

Laboratory for Electronics, Inc. 1313
Landis & Gyr, Inc. 1272
Leeds & Northrup 1278
Leslie Co. 1318, 1319
Lewis Engineering Co. 1219
Liquidometer Corp. 1424
Lynn, Robert M. 1434

Manostat Corporation 1409
Marsh Instrument Company, Division of Colorado Oil and Gas Corporation 1386
Marshalltown Mfg. Company 1425
Martin-Decker Corporation 1395
Marx Co., Clarence J. 1434
*MASSA a Division of Cohu Electronics, Inc. 1422
Marcold Corporation 1390
Mine Safety Appliances Company 1286, 1287
Minneapolis-Honeywell Regulator Co. 1233, 1235, 1268, 1269, 1334, 1335, 1355, 1356
Moeller Instrument Company, Inc. 1378
Moser Jewel Company 1395
Mason Instrument Company 1434

Nash Engineering Company 1379
New Brunswick General Sheet Metal Works 1421
Nesco Instruments Company 1284
Newark Electronics Corporation 1430

Offner Electronics Inc. 1263
Opto-Metric Tools, Inc. 1247

P.B.R. Mfg. Co. 1434
Pace Engineering Company 1394
Palmer Thermometers, Inc. 1426
Parabam, Inc. 1416
Philadelphia Scientific Glass Co. 1434
Philbrick Researches, Inc., George A. 1426
Photron Instrument Company 1411
Post Electronic Products Division of Reid Brothers Company, Inc. 1394
Potter Aeronautical Corp. 1232
Precision Tube Company 1428
Preis Engraving Machine Co., H. P. 1423
Pyramid Plastics, Inc. 1432

Radiation Electronics Co. 1420
Raytheon Company, Equipment Division 1373
Reeves Soundcraft Corp. 1265
Renick Co., L. C. 1418
Rescon Electronics Corporation 1380
Rockwell Manufacturing Company 1353
Rogan Brothers 1397
Rosemount Engineering Company 1384

SKF Industries, Inc. 1377
Sanborn Company 1275
Scam Instrument Corp. 1406
Schutte and Koerting Company 1382
Seegers Instrument Company 1247
Sensitive Research Instrument Corporation 1220
Shore Instrument & Mfg. Co., Inc. 1396
Spellman High Voltage Co. 1423
Spence Engineering Company, Inc. 1375
Stearns Electric Corporation 1372
Sticht Co., Inc., Herman H. 1396, 1418
Strahman Valves, Inc. 1406
Stratos Division, Fairchild Engine & Airplane Corp. 1413
Superior Tube Company 1339
Swartwout Division, Crane Co. 1393
Synchro-Start Products, Inc. 1382

Technique Associates 1395
Telechrome Manufacturing Corp. (Clary Corp.) 1290
Teletype Corporation 1361
Tenney Engineering, Inc. 1367
Texas Instruments Incorporated 1249
Thermo-Couple Products Co. Inc. 1395
Thermo Electric Co., Inc. 1288
Tigerman Engineering Co. 1428

Uehling Instrument Co. 1432
Unerti Optical Co., John 1394
Uniflow Valve Corporation 1360
Ucinite Company, Division of United-Carr Fastener Corporation 1421
United Electric Controls Company 1266

Varian Associates 1418

Wallace & Tiernan Incorporated 1407
Welch Scientific Company, W. M. 1369
West Instrument Corporation 1429
Western Electronic Products Co. 1434
Weston Instruments Div., Daystrom, Inc. 1323
Wilkerson Corporation 1231
Worley Jewel Co., John 1425

Yarnall-Waring Company 1354

Zeiss, Inc., Carl 1405

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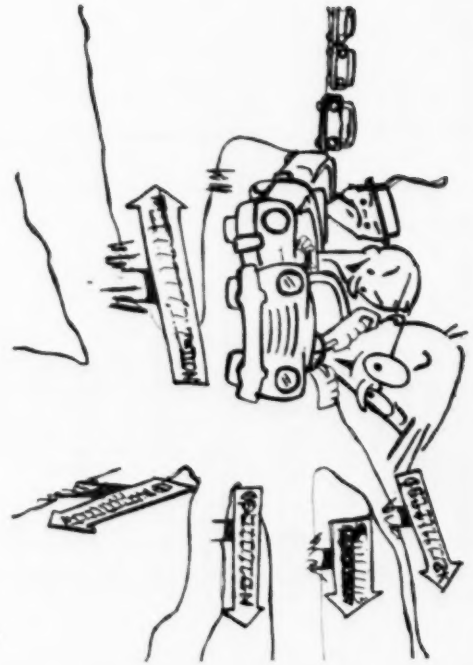

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3	23	43	63	83	103	123	143	163	183	203	223	243	263	283	303	323	343	363	383	403	423	443
4	24	44	64	84	104	124	144	164	184	204	224	244	264	284	304	324	344	364	384	404	424	444
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6	26	46	66	86	106	126	146	166	186	206	226	246	266	286	306	326	346	366	386	406	426	446
7	27	47	67	87	107	127	147	167	187	207	227	247	267	287	307	327	347	367	387	407	427	447
8	28	48	68	88	108	128	148	168	188	208	228	248	268	288	308	328	348	368	388	408	428	
9	29	49	69	89	109	129	149	169	189	209	229	249	269	289	309	329	349	369	389	409	429	
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11	31	51	71	91	111	131	151	171	191	211	231	251	271	291	311	331	351	371	391	411	431	
12	32	52	72	92	112	132	152	172	192	212	232	252	272	292	312	332	352	372	392	412	432	
13	33	53	73	93	113	133	153	173	193	213	233	253	273	293	313	333	353	373	393	413	433	
14	34	54	74	94	114	134	154	174	194	214	234	254	274	294	314	334	354	374	394	414	434	
15	35	55	75	95	115	135	155	175	195	215	235	255	275	295	315	335	355	375	395	415	435	
16	36	56	76	96	116	136	156	176	196	216	236	256	276	296	316	336	356	376	396	416	436	
17	37	57	77	97	117	137	157	177	197	217	237	257	277	297	317	337	357	377	397	417	437	
18	38	58	78	98	118	138	158	178	198	218	238	258	278	298	318	338	358	378	398	418	438	
19	39	59	79	99	119	139	159	179	199	219	239	259	279	299	319	339	359	379	399	419	439	
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Abacus, 237
Accelerator, Linear, 292
Accelerometer, 25, 374
Air Compressor, 32
Air-Dryer, Filter, 22, 372, 402, 403
Air Switch, 269
Amplifiers, 161, 188, 290
Amplifier, DC, 24
An/Dig. Converter, 72, 106, 252
Annunciators, 29, 154, 190, 333
Arc Control, 1

Batteries, 52
Bearings, 27, 110, 149, 185
Bellows, 46, 47, 48, 49, 355
Bridge, 147, 202, 353

Cabinet, 139, 178
Calibration Standard, 166
Capacitor, 340
Centrifuge, 443
Chart Drive, 92
Charts, 40, 71, 123, 138
Chopper, 316, 341
Clutch, 105
Computer, Analog, 74, 75, 76, 77, 188, 297, 331, 367, 368, 408
Computer, Digital, 91, 94, 258, 291
Computer Control, 258
Conductivity Diff., 5, 7, 8, 10, 11, 12, 13, 14, 365
Contacts, 81
Control Systems, 440
Controller, 26, 35, 253, 254
Correction Computer, 297
Counters, 4, 100, 104, 126, 146
Current Regulators, 42

Data Reduction Systems, 78, 106, 225, 226, 245, 404, 405, 406, 409, 410, 411, 412, 413
Density, 124
Digital Clock, 104
Digital Instruments, 100
Digital Modules, 298
Digital Readout, 184
Digital Systems, 88, 160
Digital Translator, 54
Digital Voltmeter, 246 260, 275, 320, 432
Displacement Trans., 243
Drilling, 229

Electrical Inst., 103, 147, 312, 424, 429, 430, 431
Electrometer, 369
Electronic Control, 113, 125
Electronic Equipment, 193, 433, 434, 435
Engraver, 141, 173, 181
Environmental Test, 99, 305, 335, 345, 357, 422

Flexible Coupling, 47
Flowmeter, 23, 103, 115, 150, 211, 256, 277, 315, 349, 384, 385, 387, 401
Force, 389
Frequency Standard, 325
Fuel Cell, 247
Function Generator, 77, 300
Furnace, 1
Fused Quartz, 83

Gas Analyzer, 70, 82, 151, 152, 248, 250, 337, 370
Glass & Mirrors, 194, 234

Hardness Tester, 135
Hermetic Seal, 46
Humidity, 70, 228
Hydrogen Det., 82

Infrared, 70, 152, 427
Ink Pen, 65, 69
Insulation Test, 134, 210
Integrators, 360
ITV, 442

Jacks, 177
Jewel, 131, 149, 185

Knobs, 137

Leak Detector, 9
Level, 103, 118, 183, 198, 211, 386, 447

Machine Tool Control, 257
Magnetic Disc Mem., 79
Magnetic Tape, 55, 264
Maintenance, 36
Manometers, 133, 211, 299, 346
Maximum Meter, 271
Medical, 445
Memory, 268
Micrometer, 326
Microscope, 34
Motor, 230
Motor Control, 323

Networks, 180
Noise Analyzer, 282, 358
Numerical Control, 257

Optics, 128, 142, 194
Oscilloscope, 18, 276, 351, 425
Oxygen Indicator, 6, 80, 82

Paint, Heat Res. 321
Panel Meter, 21, 31, 271, 376
Panels, 178
Patents, 446
Photoelectric Control, 209, 293
Photography, 438
Pilot Lights, 232
Pneumatic Trans., 33
Position Ind., 327
Potentiometers, 31, 129, 233, 266
Power Amplifier, 95
Power Supplies, 117, 166, 189, 197, 270, 273, 330, 332, 339, 363, 426, 428
Precision Transducer, 127
Pressure and Vacuum, 56, 150
Pressure Control, 73, 108, 122, 145, 311
Pressure Diff., 28, 43, 44, 45, 93
Pressure Gages, 119, 132, 155, 156, 163, 171, 186
Pressure Snubber, 378
Pressure Standard, 143
Pressure Switches, 43, 44, 45, 231, 328
Pressure Transducer, 287, 288, 294, 309, 347, 364, 390, 391, 392, 436
Process Control, 58, 59, 88, 108, 113, 118, 121, 125, 211
Pulse Generator, 267
Pump, 101
Pyrometer, 176, 200, 289, 348

Radioactivity, 317, 319, 366
Recorders, 37, 38, 39, 53, 63, 66, 68, 86, 89, 99, 102, 103, 121, 140, 161, 172, 179, 251, 277, 313, 322, 329, 414, 415, 416
Relays, 85, 114
Resin Kit, 278
Resistance Test, 134, 147, 210
Resistors, 308

Scales, 173
Scope Dolly, 199
Servo Motor, 195
Soldering Tools, 50
Solenoid, 114
Specific Gravity, 124, 304
Spectrometer, 317
Standards Instruments, 80
Steam Trap, 280
Strain Gages, 273, 392
Switches, 85, 310

Tachometers, 174, 203, 207
Tape Programmer, 279
Telemeter, 67, 97, 208, 245, 307, 407, 444
Temperature Control, 64, 84, 192, 249, 382
Temperature Monitoring, 2, 19, 84, 111, 112, 117, 157, 159, 162, 165, 187, 235, 263, 343
Testing Apparatus, 261, 344, 417, 418, 419, 421, 423
Thermocouple, 20, 129, 130, 136, 157, 175, 324, 373, 381, 439
Thermometer, 111, 157, 176, 187, 244, 348, 371, 383
Thermostat, 204
Time Delay Relays, 41
Timer, 103, 104, 107, 192, 301, 302, 306, 318, 374, 394, 395, 396, 397, 398
Tools, 201, 205, 206
Transistor Tester, 112, 262
Tube Fittings, 57
Tube Tools, 61
Tubing, Capillary, 87
Tubing, 120, 191, 196, 227, 296, 437, 441
Tunnel Diode Test, 303

Ultrasonic Sensor, 118

Vacuum, 56, 101, 158, 342, 356, 393
Valve Actuator, 121, 242
Valve, 283, 362, 377, 380, 388
Valve, Ball, 62
Valve, Butterfly, 336
Valves, Control, 30, 51, 59, 90, 96, 116, 167, 380
Valves, Relief, 314, 379
Valve, Sampling, 281, 283
Valves, Solenoid, 144, 350
Variable Speed, 164, 295
Vibration, 169, 361, 399, 400
Viscometer, 255
Voltage Generator, 77
Voltage, High, 153, 182, 210, 338, 420
Voltmeter, 21, 80, 246, 260, 272, 275, 320, 338, 432
VTVM, 274, 352, 354

Water Analyzer, 359
Welder, 210, 334
Weight, 109, 265
Wire Stripper, 205

X-Y, 212

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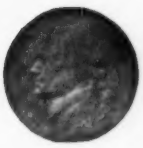

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3	23	43	63	83	103	123	143	163	183	203	223	243	263	283	303	323	343	363	383	403	423	443
4	24	44	64	84	104	124	144	164	184	204	224	244	264	284	304	324	344	364	384	404	424	444
5	25	45	65	85	105	125	145	165	185	205	225	245	265	285	305	325	345	365	385	405	425	445
6	26	46	66	86	106	126	146	166	186	206	226	246	266	286	306	326	346	366	386	406	426	446
7	27	47	67	87	107	127	147	167	187	207	227	247	267	287	307	327	347	367	387	407	427	447
8	28	48	68	88	108	128	148	168	188	208	228	248	268	288	308	328	348	368	388	408	428	
9	29	49	69	89	109	129	149	169	189	209	229	249	269	289	309	329	349	369	389	409	429	
10	30	50	70	90	110	130	150	170	190	210	230	250	270	290	310	330	350	370	390	410	430	
11	31	51	71	91	111	131	151	171	191	211	231	251	271	291	311	331	351	371	391	411	431	
12	32	52	72	92	112	132	152	172	192	212	232	252	272	292	312	332	352	372	392	412	432	
13	33	53	73	93	113	133	153	173	193	213	233	253	273	293	313	333	353	373	393	413	433	
14	34	54	74	94	114	134	154	174	194	214	234	254	274	294	314	334	354	374	394	414	434	
15	35	55	75	95	115	135	155	175	195	215	235	255	275	295	315	335	355	375	395	415	435	
16	36	56	76	96	116	136	156	176	196	216	236	256	276	296	316	336	356	376	396	416	436	
17	37	57	77	97	117	137	157	177	197	217	237	257	277	297	317	337	357	377	397	417	437	
18	38	58	78	98	118	138	158	178	198	218	238	258	278	298	318	338	358	378	398	418	438	
19	39	59	79	99	119	139	159	179	199	219	239	259	279	299	319	339	359	379	399	419	439	
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8/60

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Announcing a complete line of Manometers as Trimount Instruments joins General Controls

Through the acquisition of the Trimount Instrument Company, General Controls now offers a complete line of modern, accurate manometric instruments for every application. This famous product line will continue to be produced to the same high engineering standards that have brought broad acceptance to both Trimount and General Controls in the industrial instrumentation field. And all products manufactured and distributed by the Trimount Instrument Division will be sold and serviced through General Controls' international network of factory branch offices. Also included in the Trimount line are the "Crown" Hydraulic Remote Control Systems and the Electronic Level Indicators/Controllers.

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Line includes capacitance type on-off Controllers. Also transistorized linear and proportioning Level Indicators/Controllers, designed for use with liquids, gases and solids – including cryogenic materials.

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Self-contained hydraulic systems for positive, infinite positioning of remotely located levers, guides, valves or actuators.

Manufacturers of Manometers, Electronic Level Indicators/ Controllers and Hydraulic Remote Control Systems

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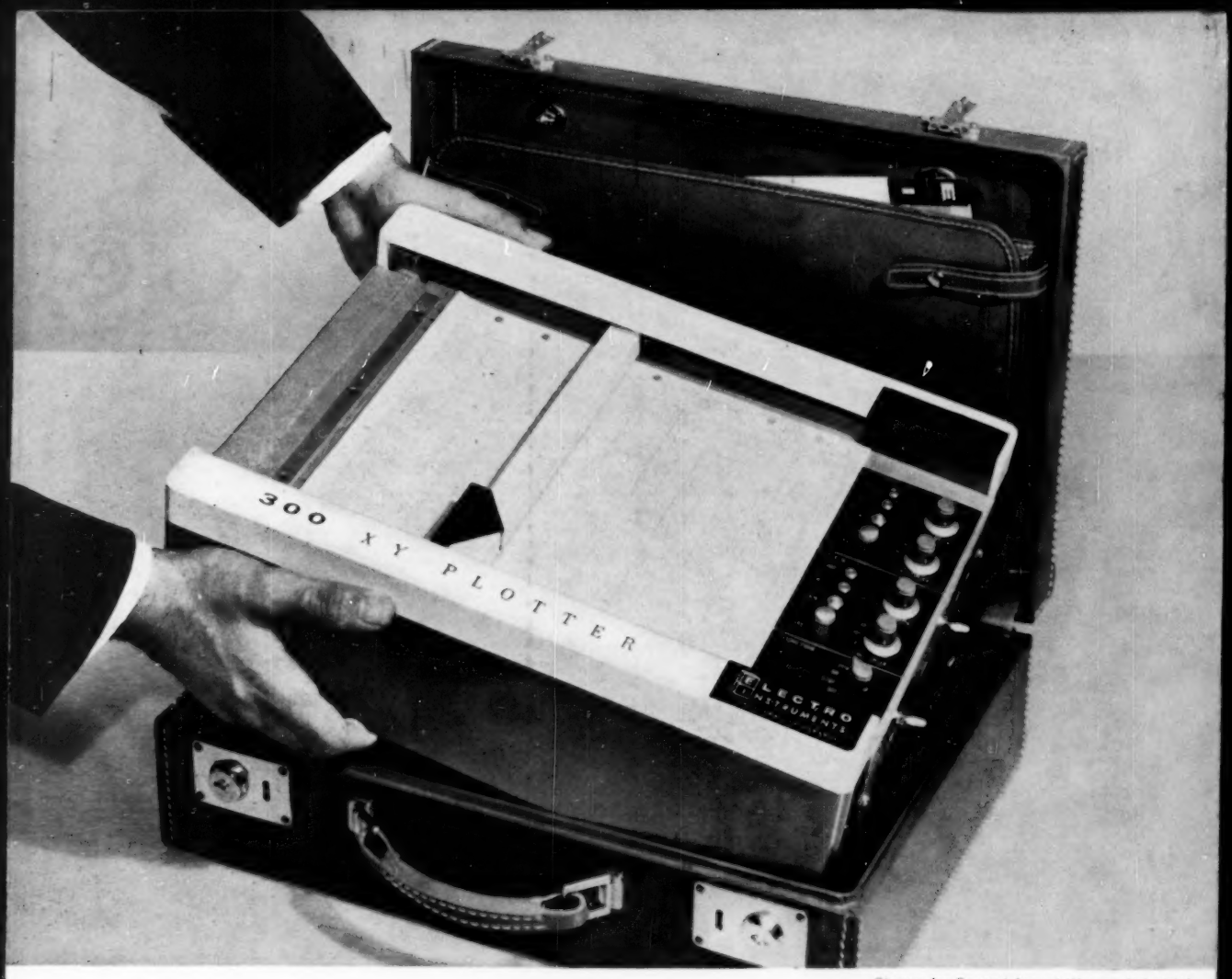

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NEW! the world's first totally-transistorized $8\frac{1}{2}$"x11" x-y recorder

...easily fits into an attache case, almost as portable! Numerous mechanical and electrical design advances have been incorporated into this completely new EI recorder. Besides greater reliability and low power dissipation resulting from its all-transistorized design, the Model 300 provides faster slewing speeds, improved accuracies, additional scales and ranges and other performance features to widen its application. The distinctive, modern cabinet design is "human engineered," with operating controls and inputs conveniently grouped at one end for maximum operator convenience. All electronic circuitry is contained in a single assembly that can be removed in seconds. Without a doubt, the new Model 300 is the most advanced $8\frac{1}{2}$"x11" X-Y recorder available today, developed and *proved by more than 5 years' experience.* Let your EI Field Engineer demonstrate this exciting new recorder to you. Through a nationwide staff of factory sales and service men you are assured the most for your money—before, during and after the sale. *Write today for new x-y catalog!*

SPECIFICATIONS

Paper size: 8½" x 11"
Recording size: 7" x 10"
Overall dimensions: 11½" wide x 16½" long x 5" high
Net weight: 26 lbs.
Ambient temperature range: 0° to 55° C
Power requirements: 115 ± 10 v, 60 cps, 10 watts, standby; 100 watts, operating
Slewing speeds: 20"/sec both axes
Scales: 0.5, 1.0, 2.0, 5.0 mv/in.
Multiplier: X1, X10, $X10^2$, $X10^3$, $X10^4$
Plotting accuracy: 0.15% full scale
Input impedance: 1 megohm all ranges
Reference: Internal mercury battery or external ± 100 v from computer reference

OEM discounts available on all EI x-y recorders.

Electro Instruments, Inc.

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